DRY-CLEANING SOLVENT CLEANUP ACT (DSCA) PROGRAM PFAS PILOT STUDY REPORT

Sponsored By:

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DSCA Program PFAS Pilot Study Report

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Executive Summary

The North Carolina Department of Environmental Quality (NCDEQ) Dry-Cleaning Solvent Cleanup Act (DSCA) Program conducted a pilot study to evaluate the occurrence and potential sources of per- and polyfluoroalkyl substances (PFAS) at selected dry-cleaning sites across North Carolina. The study included groundwater sampling at 14 DSCA Program sites (upgradient and source area monitoring wells) and collection of dry-cleaning process samples at five active facilities, including virgin and used solvents, waste streams, and selected cleaning products.

Groundwater data were evaluated relative to Title 15A NCAC 2L .0202 Groundwater Quality Standards (NC 2L Standards), Environmental Protection Agency (EPA) Maximum Contaminant Levels (MCLs), practical quantitation limits (PQLs), and site-specific background conditions. For perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), the PQL defined based on EPA national laboratory validation results of 4 nanograms per liter (ng/L) is higher than the numerical NC 2L Standard and serves as the NC 2L Standard as of the writing of this report. For clarity, the 4 ng/L PQL is referred to as the EPA PQL in this report, and the laboratory-specific PQLs for individual samples are referred to as the lab PQLs.

The pilot study data will be used to support DSCA Program decision-making regarding PFAS at dry-cleaning sites. The key conclusions of the pilot study are summarized below.

- PFOS and/or PFOA were detected above lab PQLs in upgradient monitoring wells at all 14 sites, and above the NC 2L Standard (equivalent to the EPA PQL) and EPA MCL in upgradient monitoring wells at nine of the 14 sites. These data suggest regional or off-site PFAS occurrence and confirm that consideration of background concentrations is an important component of PFAS assessment at dry-cleaning sites.
- Pilot study results indicated little evidence of dry-cleaning-related PFAS impacts at 36% of sites, moderate or strong evidence at 50% of sites, and inconclusive evidence at 14% of sites. Assuming the pilot sites are generally representative of the DSCA Program site inventory, these results may help provide context regarding the potential scope of future PFAS assessment efforts across the DSCA Program.
- PFOA was the most frequently detected PFAS in source groundwater at concentrations an order of magnitude or greater than background at sites with moderate to strong evidence of dry-cleaning related PFAS impacts. PFOS or PFOA were also the highest concentration PFAS at all but one site. These data, combined with the fact that PFOS and PFOA have established NC 2L Standards and EPA MCLs, suggest that PFOS and/or PFOA are key PFAS COCs for most dry-cleaning sites. Various other PFAS were detected; however, other than the predominance of PFOS and/or PFOA, review of the pilot test data did not suggest a specific PFAS signature for dry-cleaning sites.
- PFOS and PFOA concentrations observed in the NC pilot study were generally about two orders of magnitude lower than published mean groundwater concentrations at primary-source sites (for example, fire training areas and manufacturing facilities), suggesting dry cleaners represent a less significant PFAS source relative to primary-source settings.

- Sampling at a dry-cleaning distribution facility where virgin solvents were stored, but no active dry-cleaning occurred and no waste solvents were stored, showed no detectable PFAS. These results suggest that PFAS concerns are lower at distribution facilities without active cleaning operations.
- No significant PFAS were detected at the two sites that operated primarily in the 1950s and 1960s, supporting the conclusion that PFAS are less likely to be a concern at sites that operated prior to widespread PFAS use in textiles beginning in the mid to late 1960s.
- Evaluation of PFAS concentration in groundwater relative to perchloroethylene (PCE) concentrations did not indicate a significant correlation; demonstrating that PCE concentrations are not a reliable predictor of PFAS concentrations at dry-cleaning sites.
- Groundwater sampling results were inconclusive for the two sites sampled in the Coastal Plain physiographic province. Data interpretation may be complicated by unrelated sources, potential upgradient PFAS migration associated with low hydraulic gradients, or other factors. No other clear correlations between PFAS concentrations and geographic region were identified.
- Virgin PCE and petroleum solvent samples showed no detectable PFAS, while used PCE solvent samples contained elevated PFAS, supporting the conclusion that PFAS in used solvents likely reflect leaching from clothing during cleaning rather than PFAS being inherent constituents of the solvents. Analysis of used petroleum solvent samples would be a useful future study component.
- No PFAS were detected in spent wet wash water samples, although elevated PQLs may mask low-level contributions. Overall, the data indicate that used dry-cleaning solvent is likely a more significant potential source of PFAS impacts at dry-cleaning sites than spent wet wash water.
- Contact water associated with facility misters indicated laboratory-estimated PFAS detections in some post-carbon samples, but carbon changeout dates were not confirmed. Additional sampling and evaluation of carbon changeout timing and maintenance practices are warranted before drawing conclusions regarding PFAS management for mister contact water.
- PFAS were detected in some spotting agent, detergent, and additive samples collected from previously opened containers at active dry-cleaning facilities, but subsequent sampling of products purchased directly from a distributor showed no PFAS above PQLs. Given potential on-site product mixing practices by dry cleaners and uncertainty regarding formulation ages, the representativeness of samples collected from previously opened containers at dry-cleaning facilities is uncertain. Regardless, these products are typically used in relatively small quantities and therefore represent a lower-magnitude potential PFAS source compared to spent dry-cleaning solvents.
- Standard targeted analyses showed negligible precursor detections in groundwater, while standard analyses of used solvent samples indicated significant precursor detections. Total oxidizable precursor (TOP) Assay results also indicated substantial precursor contributions not captured by standard methods in both groundwater and used solvent samples. These

data indicate PFAS precursors are an important consideration and underscore the complexity of PFAS fate, transport, and data interpretation at dry-cleaning sites.

1.0 Introduction

PFAS are a diverse group of synthetic chemicals that have been used in industrial and consumer applications since the mid-20th century. In the textile industry, PFAS have been widely used for waterproof membranes and surface finishes to impart water-, oil-, and stain-resistance. They have also been used as processing agents to aid in the deposition of dyes and bleaches and to reduce foaming in textile treatment baths (MPCA, 2023). Due to their persistence, mobility, and potential toxicity, PFAS have become a significant focus of environmental investigations nationwide.

Although PFAS are not known constituents of typical chlorinated and petroleum-based dry-cleaning solvents themselves, prior studies have identified evidence of PFAS impacts at dry-cleaning sites. The most notable study to date was completed by the Florida Department of Environmental Protection (FDEP) at 15 pilot study sites in 2021. This study generally concluded that dry-cleaning and/or wet laundry activities contributed to PFAS concentrations in the vicinity of the pilot study sites. PFAS were identified in some raw cleaning products; however, the primary source appeared to be PFAS in wastes resulting from PFAS leaching from fabrics during laundry or dry-cleaning processes (FDEP, 2021). Note that recent studies indicate that PFAS may be present in some newer replacement solvents, but these less common solvents were not the focus of this study (ITRC, 2026).

To evaluate whether similar conditions exist in North Carolina, the NCDEQ DSCA Program initiated a pilot study to assess the occurrence and potential sources of PFAS at selected DSCA Program sites across the state. The primary objectives of the study were to determine whether PFAS pose a concern at dry-cleaning sites in North Carolina, to identify possible sources, and to provide a technical foundation for future programmatic decision-making. Hart & Hickman, PC (H&H) was contracted to implement the study, which included the following:

- Groundwater samples were collected from existing monitoring wells at 14 DSCA Program sites. At each site, samples were collected from an upgradient monitoring well to establish background conditions and from the site monitoring well with the highest concentrations of dry-cleaning solvent constituents of concern.
- Samples referred to as “dry-cleaning process samples” in this report include virgin solvent, used solvent, the facility’s raw water source, post-wet wash water, contact water in the facility mister pre- and post-carbon, detergents, spotting agents, and additives. Process samples were collected from five active dry-cleaning facilities. In addition, some samples were collected from products purchased directly from a dry-cleaning product distributor.

This report has been prepared to document evaluation of the pilot study data and conclusions based on the results of the pilot study.

2.0 Site Selection

H&H evaluated DSCA Program sites across the State of North Carolina to develop a list of locations representing a broad range of conditions. As part of the site selection process, the information detailed below was considered.

<u>Geographic Locations</u>

- Sites were selected to represent a range of geographic locations, including sites in the Mountain, Piedmont, Triassic Basin, and Coastal Plain physiographic provinces.

<u>Facility Operations</u>

- Sites using both chlorinated solvents and petroleum solvents were included in the study.
- One dry-cleaning solvent distribution facility was included in the study. Virgin solvents were stored at this site, but no active dry-cleaning was performed and no waste solvents were stored.

<u>Operational Dates</u>

- PFAS usage started to become more prominent in textiles in the mid to late 1960s (MPCA, 2023). One site that operated through the late 1950s before PFAS prominence was included in the study. One additional site that operated only in the 1950s and 1960s was also included. Note that no other DSCA Program sites were identified that met this date range and the other study criteria.
- Multiple sites were sampled that operated during the years of widespread PFAS textile use from the 1970s through the 2010s (MPCA, 2023).
- Certain more hazardous PFAS, including PFOS and PFOA, began to be phased out by major manufacturers starting around 2000 and continuing through the 2010s (ITRC, 2023). An attempt was made to identify a DSCA Program site operating only after the 2010s; however, no sites were identified which met this date range and the other study criteria.

<u>Range of Dry-cleaning Solvent Concentrations</u>

- Sites representing a range of concentrations of PCE, the most common dry-cleaning solvent constituent of concern (COC), were included in the study.
- One site was included in the study which was impacted primarily by releases of petroleum dry-cleaning solvent.
- Sites where remediation was performed historically, other than soil excavation, were excluded from the study, since these remediation activities could impact PFAS concentrations.

<u>Excluded Sites</u>

- Sites with no clear upgradient monitoring well were excluded from the study since determination of background concentrations is an important component of the study.
- Sites located within the area of regional PFAS impacts in North Carolina associated with the Chemours facility in Fayetteville were excluded from the study.
- Sites serviced by septic systems were excluded from the study.

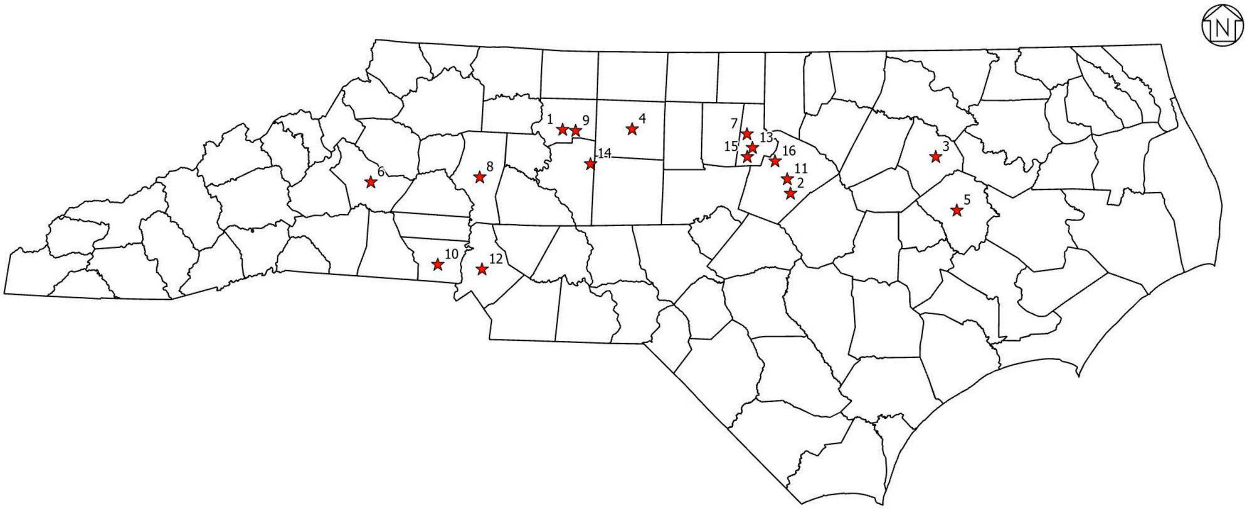
The sites selected to be a part of the pilot study and details regarding the above-referenced criteria for each site are summarized in **Table 1**. Site locations are depicted on **Figure 1**.

Table 1 – Summary of Pilot Study Sites

Study Site ID	DSCA Site ID	Years of Dry Cleaner Operation	Approximate Years of Dry-Cleaning	Solvent Used	Maximum Groundwater PCE Concentration	Geologic Region	Type of Sampling
1	DC340005	1960-Present	65	PCE	5.4 mg/L	Piedmont	Groundwater & Process
2	DC920051	1970-2024 (PCE); 2024-Present (petroleum)	55	PCE	5.8 mg/L	Piedmont	Groundwater
3	DC330005	1960s-1990s	30	Petroleum	N/A	Coastal Plain	Groundwater
4	DC410009	1964-1970 / 1975-1998	28	PCE	78 mg/L	Piedmont	Groundwater
5	DC740014	1969-1985	16	PCE (assumed)	1.3 mg/L	Coastal Plain	Groundwater
6	DC120001	1964-2003	39	PCE & Petroleum	240 mg/L	Mountain	Groundwater
7	DC320014	1987-2009	22	PCE	0.14 mg/L	Triassic Basin	Groundwater
8	DC490007	1950s-1960s	20	PCE (assumed)	1.2 mg/L	Piedmont	Groundwater
9	DC340039	1985-2017*	32*	PCE & Petroleum Distribution*	4.3 mg/L	Piedmont	Groundwater
10	DC360006	1966-Present (PCE); 2012-Present (petroleum)	59	Petroleum & PCE	2.0 mg/L	Piedmont	Groundwater & Process
11	DC920056	Unknown-late 1950s	10	PCE (assumed)	0.37 mg/L	Piedmont	Groundwater
12	DC600093	1970s-2000s	40	PCE (assumed)	0.37 mg/L	Piedmont	Groundwater
13	DC320038	1970s-1980s	10	PCE (assumed)	0.0967 mg/L	Triassic Basin	Groundwater
14	DC290002	1960-2000 (PCE) 2000-Present (petroleum)	65	PCE & Petroleum	36 mg/L	Piedmont	Groundwater & Process
15	DC320021	1995-Present	10	PCE	0.020 mg/L	Triassic Basin	Process
16	920025C	1997-Present	9	PCE	N/A	Piedmont	Process

Notes:
N/A = Not applicable; no groundwater sampling has been performed at Site 16 and site 3 is a petroleum release site with no detectable PCE.
* = Site 9 was a dry-cleaning solvent distribution facility; no active dry-cleaning or waste solvent storage was performed on-site.

Figure 1 – Locations of Pilot Study Sites



3.0 Sampling Protocols

At each of the 14 sites where groundwater sampling was performed, groundwater samples were collected from an upgradient monitoring well and the monitoring well with the highest observed concentrations of dry-cleaning solvent COCs. Groundwater sampling procedures and quality assurance/quality control (QA/QC) procedures were generally in accordance with EPA Laboratory Services & Applied Science Division (LSASD) groundwater sampling protocols for PFAS, effective March 20, 2025. Figures showing the wells sampled at each site with respect to the groundwater flow direction and dry-cleaning solvent plume are included in **Attachment 1**.

For the dry-cleaning process samples, the specific samples collected varied for each site based on availability and permissions granted by the dry-cleaning business operator. In addition, H&H purchased raw PCE solvent and several spotting agents directly from a dry-cleaning product distributor, FabriClean Supply, used by many dry cleaners in NC. No EPA protocols have been established for process sampling, but care was taken to collect representative samples. Additional discussion of the types of process samples is included in Section 7.0.

Groundwater samples were analyzed by EPA Method 1633A for the method-specified analyte list plus hexafluoropropylene oxide dimer acid (HFPO-DA, also known as GenX). At the recommendation of the laboratory, process samples were analyzed by EPA Method 537 for the method-specified PFAS analyte list plus HFPO-DA. Due to the nature of the samples (commercial products and wastes with potentially high concentrations of unconfirmed analytes), the laboratory diluted the samples before analysis to protect their equipment which resulted in elevated PQLs and method detection limits (MDLs) for this data set. Some samples were also analyzed by TOP Assay to assess for the presence of PFAS precursors.

Field blanks, equipment blanks, duplicate samples, and laboratory blanks were analyzed as appropriate for QA/QC. For the most part, QA/QC samples indicated that data were usable for the purposes of the pilot study. Where QA/QC samples indicated significant concerns, that data are flagged accordingly in this report. Refer to the separate DSCA Program PFAS Pilot Study Supplemental Report for a more detailed discussion of sampling procedures, QA/QC protocols, and laboratory analytical reports.

4.0 PFAS Nomenclature

For clarity, **Table 2** lists the nomenclature for the PFAS discussed in this report. Compounds are divided into short-chain, long-chain, and precursor PFAS for convenience. There has been a manufacturing shift away from long-chain PFAS toward short-chain PFAS and other replacement compounds, driven by concerns that certain long-chain PFAS are more persistent, bioaccumulative, and may pose human health risks at lower doses. This report refers to short-chain and long-chain PFAS for organizational purposes; however, toxicity data are limited for many PFAS, particularly short-chain and replacement compounds, and PFAS behavior and toxicity should not be generalized based solely on chain length.

- Long-chain PFAS refer to perfluoroalkyl carboxylic acids (PFCAs) with eight or more carbons (seven or more carbons are perfluorinated) and perfluoroalkane sulfonic acids (PFSAs) with six or more carbons (six or more carbons on perfluorinated).
- Short-chain PFAS refer to PFCAs with seven or fewer carbons (six or fewer carbons are perfluorinated) and PFSAs with five or fewer carbons (five or fewer carbons on perfluorinated).
- PFAS precursors refer to PFAS that may transform into other more persistent terminal PFAS in the environment (ITRC, 2023).

Table 2 – PFAS Nomenclature

Category	Abbreviation	PFAS Compound
Short-Chain PFAS	PFBA	Perfluorobutanoic acid
	PFBS	Perfluorobutanesulfonic acid
	PFPeA	Perfluoropentanoic acid
	PFPeS	Perfluoropentanesulfonic acid
	PFHxA	Perfluorohexanoic acid
	PFHpA	Perfluoroheptanoic acid
	PFMPA	Perfluoro-3-methoxypropanoic acid
	HFPO-DA	Hexafluoropropylene oxide dimer acid (GenX)
Long-Chain PFAS	PFHxS	Perfluorohexanesulfonic acid
	PFHpS	Perfluoroheptanesulfonic acid
	PFOA	Perfluorooctanoic acid
	PFOS	Perfluorooctanesulfonic acid
	PFNA	Perfluorononanoic acid
	PFDA	Perfluorodecanoic acid
	PFDS	Perfluorodecanesulfonic acid
	PFUnA	Perfluoroundecanoic acid
	PFDoA	Perfluorododecanoic acid
	PFDoS	Perfluorododecanesulfonic acid
	PFTrDA	Perfluorotridecanoic acid
	PFTeDA	Perfluorotetradecanoic acid

Category	Abbreviation	PFAS Compound
PFAS Precursors	3:3 FTCA	3-Perfluoropropylpropanoic acid
	5:3 FTCA	3-Perfluoropentylpropanoic acid
	7:3 FTCA	3-Perfluoroheptylpropanoic acid
	PFOSA	Perfluorooctanesulfonamide
	NEtFOSA	N-ethylperfluorooctane sulfonamide
	NEtFOSE	N-ethylperfluorooctane sulfonamidoethanol
	NEtFOSAA	N-ethylperfluorooctanesulfonamidoacetic acid
	NMeFOSE	N-methylperfluorooctane sulfonamidoethanol
	NMeFOSA	N-methylperfluorooctane sulfonamide
	NMeFOSAA	N-methylperfluorooctanesulfonamidoacetic acid
	6:2 FTS	1H,1H,2H,2H-Perfluorooctane sulfonic acid
	8:2 FTS	1H,1H,2H,2H-Perfluorodecane sulfonic acid

Note:
Table includes PFAS detected in at least one sample collected as part of the pilot study.

5.0 Regulatory and Data Screening Framework

Concentrations of PFAS detected in groundwater samples were compared to action levels established by the State of North Carolina and the EPA, as well as background levels. Details regarding the specific action levels are provided below. Because no specific regulatory criteria apply to the dry-cleaning process samples, those data were evaluated using a more general qualitative approach.

5.1 North Carolina Action Levels

In November 2025, the NCDEQ Division of Water Resources established NC 2L Standards for PFOS, PFOA, and HFPO-DA (i.e., GenX). The NC 2L Standards for PFOS and PFOA were established at 0.7 ng/L and 0.001 ng/L, respectively. However, pursuant to the Fiscal and Regulatory Impact Analysis Amendment to 15A NCAC 02L .0202 dated August 14, 2024 (herein referred to as the Amendment), the PQLs as defined in 15A NCAC 02L .0102 serve as the regulatory limit for PFOS and PFOA unless and until the PQLs decrease to a level that is at or below the standard. The PQLs for PFOS and PFOA defined in the Amendment based on EPA national laboratory validation results and effective as of the writing of this report are both 4 ng/L. For clarity, the 4 ng/L PQL is referred to as the EPA PQL in this report, and the laboratory-specific PQLs for individual samples are referred to as the lab PQLs. The EPA PQL of 4 ng/L serves as the applicable NC 2L Standard for PFOS and PFOA.

NC 2L Standards
PFOS 4* ng/L
PFOA 4* ng/L
HFPO-DA 10 ng/L
* - EPA PQL

5.2 EPA Action Levels

In April 2024, the EPA established individual MCLs for five PFAS in drinking water, including PFOA, PFOS, PFHxS, PFNA, and HFPO-DA (i.e., GenX). The EPA also established an MCL for PFAS mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS using a Hazard Index (HI) approach to account for the combined levels of these PFAS in drinking water. As part of the pilot study, groundwater concentrations were compared to the EPA MCLs for individual constituents, where established. The hazard index for combined concentrations of PFHxS, PFNA, HFPO-DA, and PFBS was not calculated for simplicity. EPA MCLs are provided for reference only and NC 2L Standards are more pertinent for monitoring well samples. Accordingly, the data evaluation described in this report focuses more on exceedances of NC 2L Standards rather than EPA MCLs.

EPA MCLs
PFOS 4 ng/L
PFOA 4 ng/L
PFHxS 10 ng/L
PFNA 10 ng/L
HFPO-DA 10 ng/L
HI 1.0 for select mixed PFAS

Note that EPA issued a notice in May 2025 indicating its intent to rescind the regulations and reconsider the regulatory determinations for PFHxS, PFNA, HFPO-DA, and the Hazard Index mixture of these three plus PFBS. However, the notice does not indicate EPA intends to rescind the regulatory determinations for PFOS and PFOA (EPA, 2025). In addition, as of the date of this report, the April 2024 EPA MCLs remain in effect.

5.3 Background Concentrations

Background concentrations of PFAS at each site are generally assumed to be equal to concentrations in upgradient monitoring wells for the purposes of this study. This approach is considered reasonable because the upgradient wells are located hydraulically upgradient of the PCE plumes and are therefore expected to represent groundwater conditions not influenced by site-related releases. However, for individual site regulation purposes, additional data evaluation may be needed in some cases to establish true background concentrations for each specific site.

6.0 Groundwater Sample Results and Data Evaluation

The full set of PFAS analytical data for groundwater samples is included in the DSCA Program PFAS Pilot Study Supplemental Report. The following sections summarize the key groundwater sample results and data evaluation.

6.1 Evidence of Regional and Upgradient PFAS Occurrence

Dry-cleaning facilities are often located in highly populated, developed areas where multiple potential PFAS sources may be present. PFAS were detected in the upgradient monitoring well at all 14 sampled sites. Furthermore, PFOS or PFOA were detected at concentrations exceeding lab PQLs in the upgradient monitoring well at all 14 sites, and at concentrations exceeding NC 2L Standards (equivalent to EPA PQL) at nine of the 14 sites. These findings confirm that PFAS are commonly present in background groundwater due to regional or off-site sources. Accordingly, determination of background concentrations is a critical component of PFAS assessment at dry-cleaning sites and was a key element of the data evaluation discussed in this report.

6.2 Site Category Based on Groundwater Concentrations

Sites were generally categorized with respect to evidence of PFAS impacts from dry-cleaning operations as follows:

- **Little evidence** - For sites DC320014, DC490007, DC340039, DC920056, and DC290002, the sampling data indicate upgradient well concentrations that are similar to or higher than source well concentrations for most detected PFAS. Where source well concentrations are higher than upgradient well concentrations, the magnitude of exceedances is generally considered negligible and well below an order of magnitude.
- **Moderate evidence** - For sites DC340005, DC410009, and DC600093, the sampling data indicate source well concentrations that are generally greater than upgradient well concentrations by less than an order of magnitude for key PFAS.
- **Strong evidence** - For sites DC920051, DC120001, DC360006, and DC320038, the sampling data indicate source well concentrations that are greater than upgradient well concentrations for key PFAS by more than an order of magnitude (for at least some PFAS).
- **Inconclusive evidence** - For sites DC330005 and DC740014, the sampling data indicate upgradient well concentrations that are higher than source well concentrations for some PFAS, although some other PFAS were also detected at higher concentrations in the source well. Additional assessment and data evaluation would be needed to confirm the source of impacts. Because the purpose of this report is to specifically evaluate PFAS associated with dry-cleaning sites, the presence of potential upgradient sources complicates interpretation of the results. For simplicity, these sites were excluded from much of the additional data evaluation discussed further in this report.

A summary of analytical data for the site categories discussed above is provided in **Table 3**. As indicated in the accompanying notes, green shading indicates background concentrations higher than or equal to source concentrations, yellow shading indicates source concentrations exceed background concentrations by less than an order of magnitude, and orange shading indicates source concentrations exceed background concentrations by an order of magnitude or more.

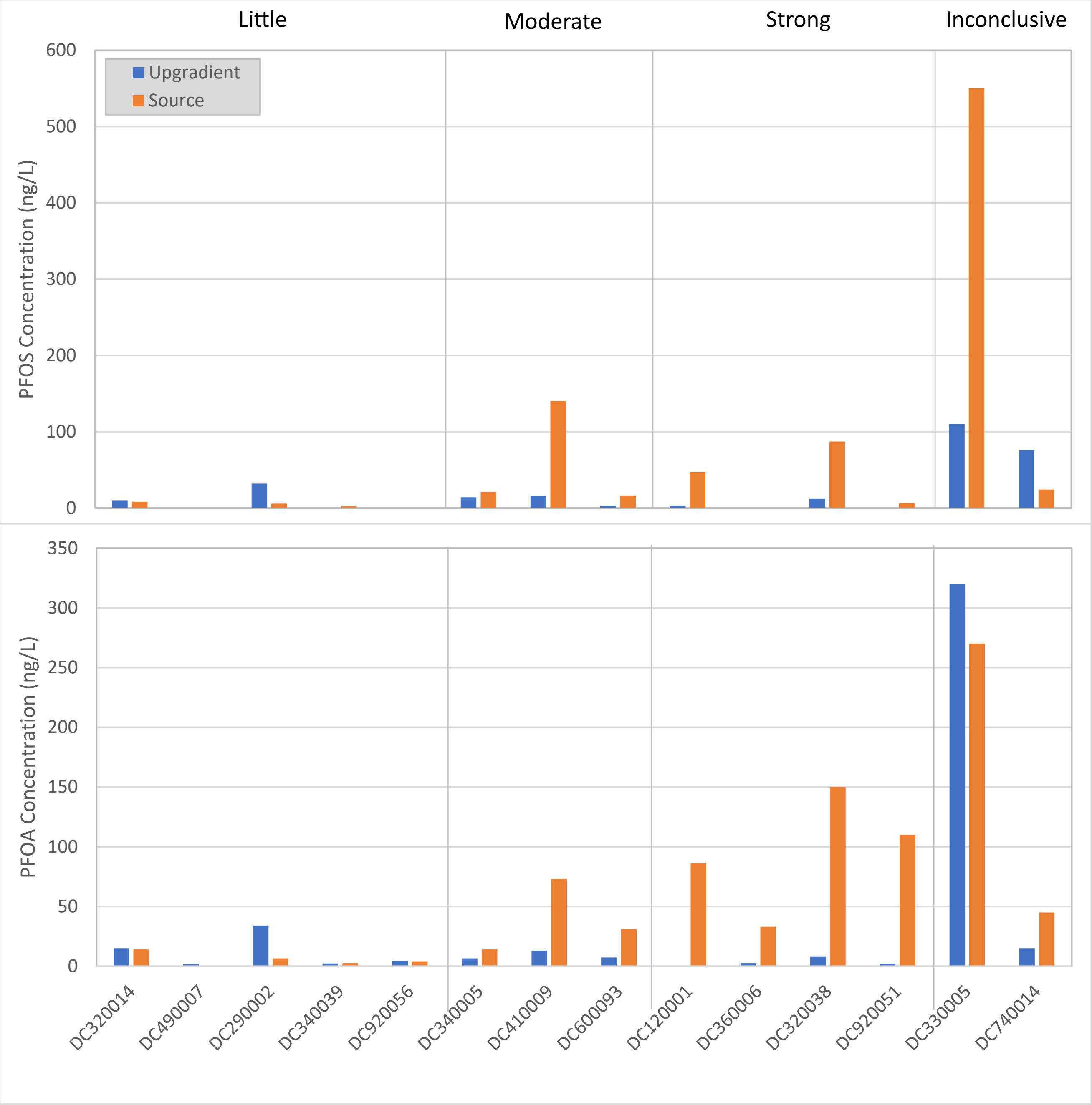
Table 3 – Groundwater Data and Evidence of PFAS Impacts from Dry-cleaning Operations

Location	Long-Chain						Short-Chain						Precursors				Total PFAS
	PFOA	PFOS	PFHxS	PFHpS	PFNA	PFDA	PFBA	PFBS	PFPeA	PFPeS	PFHxA	PFHpA	PFOSA	NEtFOSAA	NMeFOSAA	6:2 FTS	
2L Standard	4	4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
EPA MCL	4	4	10	NS	10	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Little Evidence																	
DC320014																	
Upgradient	**15**	**10**	3.2	<1.5	3.6	<1.5	9.1	15	19	0.81 J	15	8.6	<1.5	<1.5	<1.5	<3.0	99
Source	**14**	**8.2**	1.8	<1.8	2.2	<1.8	4.5	6.3	6.3	<1.8	6.5	6.0	<1.8	<1.8	<1.8	<3.6	56
DC490007																	
Upgradient	1.7	<1.5	3.3	<1.5	<1.5	<1.5	3.2	3.1	5.5	1.4 J	5.3	1.4 J	<1.5	<1.5	<1.5	<3.0	24.9
Source	<1.5	<1.5	1.6	<1.5	<1.5	<1.5	1.0 J	0.96 J	2.1	<1.5	1.7	<1.5	<1.5	<1.5	<1.5	<3.1	7.4
DC290002																	
Upgradient	**34**	**32**	5.9	0.72 J	3.2	0.50 J	8.8	19	13	0.88 J	11	9.4	<1.6	<1.6	<1.6	<3.2	138
Source	**6.5**	**5.8**	1.9	<1.6	0.48 J	<1.6	1.6 J	1.2 J	2.9	0.57 J	3.1	1.5 J	<1.6	<1.6	<1.6	<3.1	25.55
DC340039																	
Upgradient	2.3	<1.2	1.7	<1.7	<1.7	<1.7	1.6 J	1.2 J	1.9	<1.7	2.2	0.90 J	<1.7	<1.7	<1.7	<3.3	11.8
Source	2.5	2.2	1.9	<1.7	<1.7	<1.7	1.8 J	1.2 J	1.6 J	<1.7	1.9	1.1 J	<1.7	<1.7	<1.7	<3.3	14.2
DC920056																	
Upgradient	**4.4**	<1.7	7.3	<1.7	<1.7	<1.7	6.2	22	3.0	5.6	3.3	1.7	<1.7	<1.7	<1.7	<3.3	54
Source	**4.1**	<1.8	9.8	<1.8	<1.8	<1.8	3.2 J	5.0	4.0	<1.8	4.4	3.0	<1.8	<1.8	<1.8	<3.5	33.5
Moderate Evidence																	
DC340005																	
Upgradient	**6.5**	**14**	6.4	0.50 J	0.57 J	<1.6	1.6 J	6.2	1.7	1.4 J	2.8	1.8	<1.6	<1.6	<1.6	<3.1	43
Source	**14**	**21**	4.3	0.67 J	<1.5	<1.5	5.6	13	9.9	1.5	7.0	5.3	<1.5	<1.5	<1.5	<3.0	82
DC410009																	
Upgradient	**13**	**16**	5.5	<1.8	<1.6	<1.8	3.9	2.8	4.1	<1.8	5.5	5.6	<1.8	<1.8	<1.8	<3.6	56
Source	**73**	**140**	**11**	3.2	8.4	4.1	16	6.1	26	2.6	28	19	<1.8	<1.8	<1.8	<3.5	340
DC600093																	
Upgradient	**7.3**	3.0	6.1	<2.0	<2.0	<2.0	3.4 J	5.9	11	1.2 J	9.6	2.5	<2.0	<2.0	<2.0	<3.9	50
Source	**31**	**16**	7.9	<1.7	0.98 J	<1.7	7.4	9.5	21	<1.7	18	9.6	<1.7	<1.7	<1.7	<3.4	121
Strong Evidence																	
DC120001																	
Upgradient	<1.0	2.8	<1.4	<1.4	<0.43	<1.4	1.2 J	<1.4	<1.4	<1.4	<0.52	<1.4	<1.4	<1.4	<1.4	<2.9	4.5
Source	**86**	47	**14**	10	2.8	<1.5	9.8	6.4	44	3.7	24	9.1	<1.5	<1.5	<1.5	<3.0	257
DC360006																	
Upgradient	2.5	<1.6	3.7	<1.6	<1.6	<1.6	3.3	<1.6	3.4	<1.6	3.4	5.5	<1.6	<1.6	<1.6	<3.1	21.8
Source	**33**	<1.7	9.1	<1.7	<1.7	<1.7	140	280	710	2.9	390	83	<1.7	<1.7	<1.7	<3.3	1650
DC320038																	
Upgradient	**7.8**	**12**	1.5 J	<1.7	1.1 J	<1.7	17	6.5	26	<1.7	29	4.3	<1.7	<1.7	<1.7	<3.4	105
Source	**150**	**87**	9.7	2.1	**21**	2.9	140	26	100	3.2	93	61	<1.7	<1.7	<1.7	<3.3	700
DC920051																	
Upgradient	1.9	<1.7	4.5	<1.7	<1.7	<1.7	3.6	13	5.8	<1.7	6.2	5.4	<1.7	<1.7	<1.7	<3.5	40
Source	**110**	**6.3**	**17**	1.6 J	1.5 J	<1.7	35	44	96	2.0	82	89	<1.7	<1.7	<1.7	<3.4	480
Inconclusive Evidence																	
DC330005																	
Upgradient	**320**	**110**	**170**	7.2	4.1	<1.8	44	29	76	30	120	82	<1.8	<1.8	<1.8	5.1	1000
Source	**270**	**550**	**25**	6.1	**26**	8.0	38	10	47	6.0	62	78	8.6	9.9	13	<3.5	1160
DC740014																	
Upgradient	**15**	**76**	**40**	<1.2	<0.51	<1.7	<3.4	3.2	9.1	1.5 J	10	5.8	<1.7	<1.7	<1.7	<3.4	161
Source	**45**	**24**	5.9	2.0	5.1	<1.6	2.5 J	1.7	11	1.2 J	10	13	<1.6	<1.6	<1.6	<3.2	121

Notes:
Table only includes PFAS compounds detected in the associated set of groundwater samples at concentrations above lab PQLs.
Concentrations in ng/L or parts per trillion (ppt).
"<" values shown are lab PQLs.
J = Concentration above MDL but below lab PQL, refer to the DSCA Program PFAS Pilot Study Supplemental Report for additional data flags associated with depicted concentrations.
Bold = Concentrations exceed EPA MCL.
<u>Underline</u> = Concentrations exceed NC 2L Standard (equivalent to EPA PQL).
Green shading = Upgradient concentrations higher or equal to source concentrations.
Yellow shading = Source concentrations exceed upgradient concentrations by less than an order of magnitude.
Orange shading = Source concentrations exceed upgradient concentrations by an order of magnitude or more.
Upgradient = upgradient well; Source = source area well; NS = no standard

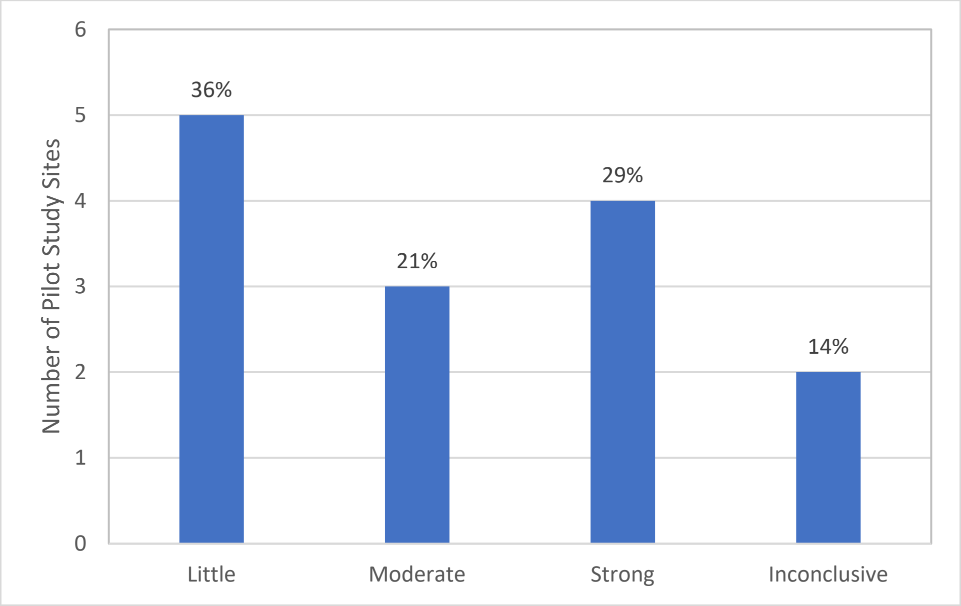
The data for little, moderate, strong, and inconclusive sites are further depicted in the bar graphs in **Figure 2** below for reference.

Figure 2 – Comparison of Upgradient vs Source Well PFOS and PFOA Concentrations



The study results indicate the percentage of sites in each category as indicated in **Figure 3**. Assuming the pilot sites are generally representative of the DSCA Program site inventory, these results may help provide context regarding the potential scope of future PFAS assessment efforts across the DSCA Program.

Figure 3 – Evidence of Impacts from Dry-cleaning Operations



6.3 Additional Data Evaluation

The following sections describe multiple approaches used to evaluate the sampling data and support the conclusions drawn from the data.

6.3.1 Key PFAS COCs

For the sites identified as having moderate or strong evidence of PFAS from dry-cleaning operations, an evaluation of the groundwater sampling data was performed to evaluate which PFAS should be considered "key" COCs for dry-cleaning sites. **Table 4** summarizes frequency of detection for PFAS COCs, and **Table 5** summarizes the PFAS COC detected at the highest concentrations in the source well at each site.

Table 4 – PFAS COC Frequency of Detection

Category	Constituent	Frequency of Detection		
		>Lab PQL	>Lab PQL & >Background	>Lab PQL & ≥10 x Background
Long-chain	PFOA	100%	100%	57%
Short-chain	PFPeA	100%	100%	43%
Short-chain	PFHxA	100%	100%	43%
Short-chain	PFHpA	100%	100%	43%
Short-chain	PFBA	100%	100%	14%
Short-chain	PFBS	100%	100%	14%
Long-chain	PFHxS	100%	86%	14%
Long-chain	PFOS	86%	86%	14%
Long-chain	PFNA	43%	43%	14%
Short-chain	PFPeS	86%	86%	0%
Long-chain	PFHpS	43%	43%	0%
Long-chain	PFDA	29%	29%	0%

Notes:
Table shows PFAS detected above lab PQLs in the source well at sites categorized as having moderate or strong evidence of PFAS impacts from dry-cleaning operations. Table is ordered by frequency of detections an order of magnitude or more above background concentrations, then by frequency of detections above lab PQLs.

Conclusions regarding the importance of the different PFAS COCs based on review of the data in **Tables 4** and **5** are discussed below. As referenced above, the data set covered in the conclusions below consists of the source well data at sites with moderate or strong evidence of PFAS from dry-cleaning operations.

Table 5 – Highest Concentration PFAS by Site

Site	PFAS at Highest Concentration in Source Well	
DC340005	PFOS	21
DC410009	PFOS	140
DC600093	PFOA	31
DC120001	PFOA	86
DC360006	PFPeA	710
DC320038	PFOA	150
DC920051	PFOA	110

Note:
Concentrations in ng/L or ppt.
Table includes sites categorized as having moderate or strong evidence of PFAS impacts from dry-cleaning operations.

PFOS & PFOA

PFOA was detected at the highest frequency above lab PQLs and an order of magnitude or more above background concentrations (57%). PFOA also has an established NC 2L Standard, which was exceeded at every sampled site, and it was the highest concentration PFAS at four of the seven sites in this data set. Therefore, PFOA is considered a key COC for NC dry-cleaning sites.

PFOS was detected less frequently above lab PQLs and an order of magnitude or more above background concentrations (14%). However, PFOS has an established NC 2L Standard, which was exceeded at six of the seven sites, and it was the highest concentration PFAS at two of the seven sites. Therefore, PFOS is also considered a key COC for NC dry-cleaning sites.

PFPeA, PFHxA, and PFHpA

After PFOA, the next highest detection frequencies above lab PQLs and an order of magnitude or more above background concentrations were observed for PFPeA, PFHxA, and PFHpA (43%). No NC 2L Standards or EPA MCLs have been established for these PFAS; however, these are short-chain compounds which generally exhibit toxicity at higher doses compared to long-chain PFAS like PFOA and PFOS.

With the exception of PFPeA at site DC360006, these constituents were not the highest detected PFAS at the seven sites in this data set. Groundwater data from site DC360006 showed elevated concentrations of short-chain PFAS relative to PFOA and PFOS. A specific operational or site-related explanation for this pattern was not identified based on available information. Overall, PFPeA, PFHxA, and PFHpA are considered notable, but the data suggest that these may not be critical COCs for most NC dry-cleaning sites.

Other PFAS

Additional PFAS detected above lab PQLs and an order of magnitude or more above background concentrations include PFHxS, PFNA, PFBA, and PFBS. These PFAS were detected at a lower frequency (14%), do not have established EPA MCLs or NC 2L Standards, and were not the highest detected PFAS at any of the seven sites in this data set. These PFAS are considered notable, but the data suggest that these may not be critical COCs for most NC dry-cleaning sites.

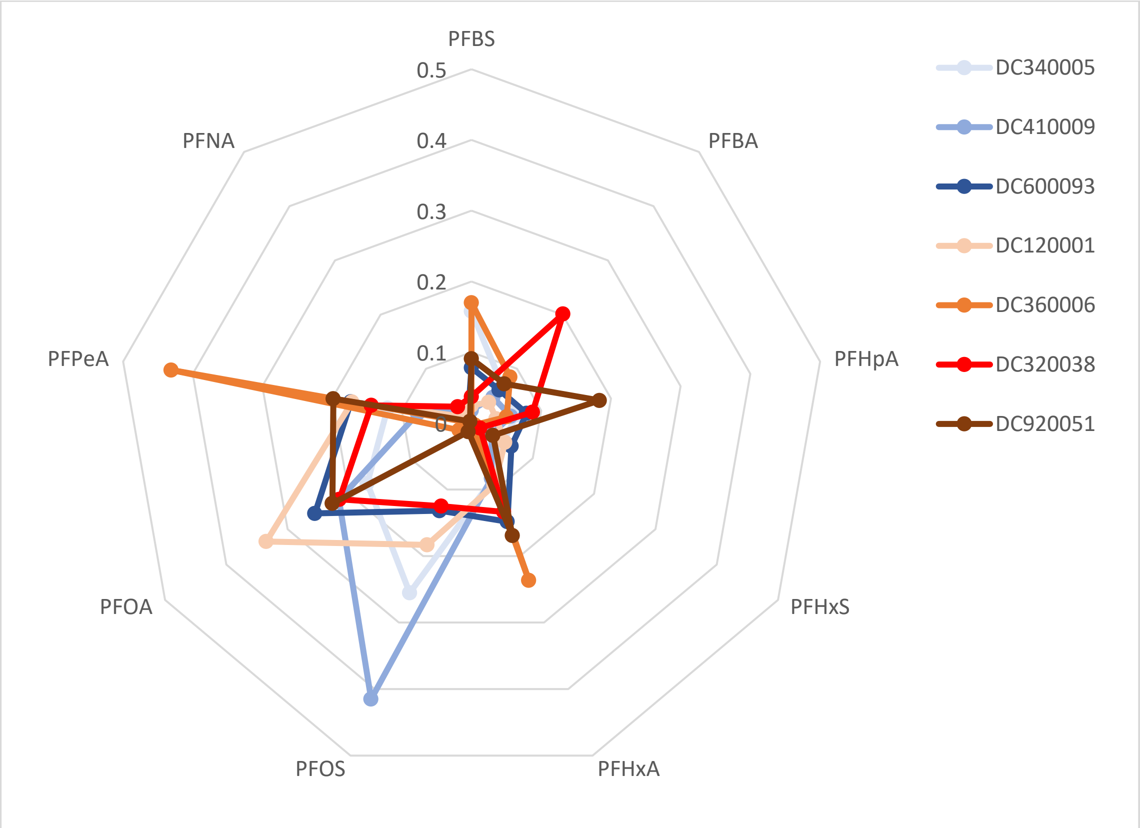
6.3.2 PFAS Groundwater Signatures

Groundwater sampling data were evaluated using the NCDEQ PFAS Signature Tool, which creates pie charts showing the different PFAS detected in each of the sampled monitoring wells. Radar graphs and bar graphs were also prepared as additional data evaluation tools.

Attachment 1 contains site maps for each of the groundwater sampling sites with PFAS Signature Tool pie charts, radar graphs, and bar graphs for the monitoring wells sampled at each site. Review of the data generally corroborates the conclusions presented in Section 6.2 regarding characterization of the sites as having little, moderate, strong, or inconclusive evidence of impacts from dry-cleaning operations. The sites characterized as strong evidence show the greatest increase in concentrations and variability in PFAS signature between upgradient and source well.

Attachment 2 contains PFAS Signature Tool pie charts and radar graphs for the source monitoring wells at the sites characterized as having moderate or strong evidence of PFAS impacts from dry-cleaning operations. The radar graph below also shows normalized PFAS concentrations in the source monitoring well for sites characterized as having moderate or strong evidence of impacts from dry-cleaning operations.

Figure 4 – Normalized Radar Graph of PFAS Concentrations in Source Monitoring Wells



Notes:
Data set includes source monitoring well data for sites in the moderate (blue shades) and strong evidence (red shades) of PFAS from dry-cleaning operations categories.
Graph is normalized to show the percentage contribution of select PFAS constituents scaled such that the total for all constituents equals one.

The normalized radar graph presented above and the pie charts in Attachment 2 generally corroborate the conclusion that PFOS and PFOA are key PFAS COCs for most dry-cleaning sites. Some other PFAS were detected, but mostly at lower concentrations and/or reduced frequency. As noted in Section 6.3.6, site DC360006 indicates a different signature than the other sampled sites, with more elevated concentrations of various short-chain PFAS as compared to PFOS or PFOA. Site DC360006 was also the only site where precursors were detected via the standard EPA Method 1633 analysis. A specific operational or site-related explanation for the elevated short-chain PFAS concentrations at this site was not identified based on review of available data.

Overall, the pilot study data generally do not suggest a specific PFAS signature profile for dry cleaners, other than the predominance of PFOS and/or PFOA, but additional trends may emerge with future data collection. Additional discussion of the groundwater signatures with respect to process sample sources is provided in Section 7.0.

6.3.3 PFAS Concentrations Relative to Other Sources

Table 6 shows the range of concentrations of PFOS and PFOA detected for sites included in the NC Study. These two constituents were selected for more detailed evaluation based on the data presented in Section 6.3.1, which indicates that PFOS and PFOA are the key PFAS COCs for dry-cleaning sites. For reference, the range of concentrations detected during the FDEP study is also shown. As indicated, concentrations detected during the NC Study were generally lower than those detected during the FDEP study. Typical concentrations for different types of sites based on published references (Johnson et al, 2022) are also shown. As indicated, maximum concentrations detected at the NC study sites were generally approximately two orders of magnitude lower than mean concentrations for primary-source sites, such as fire training areas and manufacturing plants. These data suggest that dry cleaners represent a less significant source of PFAS in the environment compared to primary-source sites.

Table 6 – Summary of PFOS and PFOA Concentration Ranges

Groundwater Concentration Source	PFOS	PFOA
NC Study	ND to 550	ND to 270
FDEP Study	40.1 to 3,480	50.9 to 2,640
Published mean for primary-source sites*	93,000	64,000
Published mean for secondary-source sites*	42	325
Published mean for no-known source sites*	46	13

Notes:
ND = Not detected above MDL
Concentrations in ng/L or ppt.
* Indicates weighted mean concentration reported in Johnson, et al, 2022. Primary-source sites include fire-training areas and manufacturing plants. Secondary-source sites include biosolids application, treated wastewater use, and landfills. No-known source sites include sites with no identified nearby PFAS source.

6.3.4 PFAS Concentrations Relative to Facility Operational Information

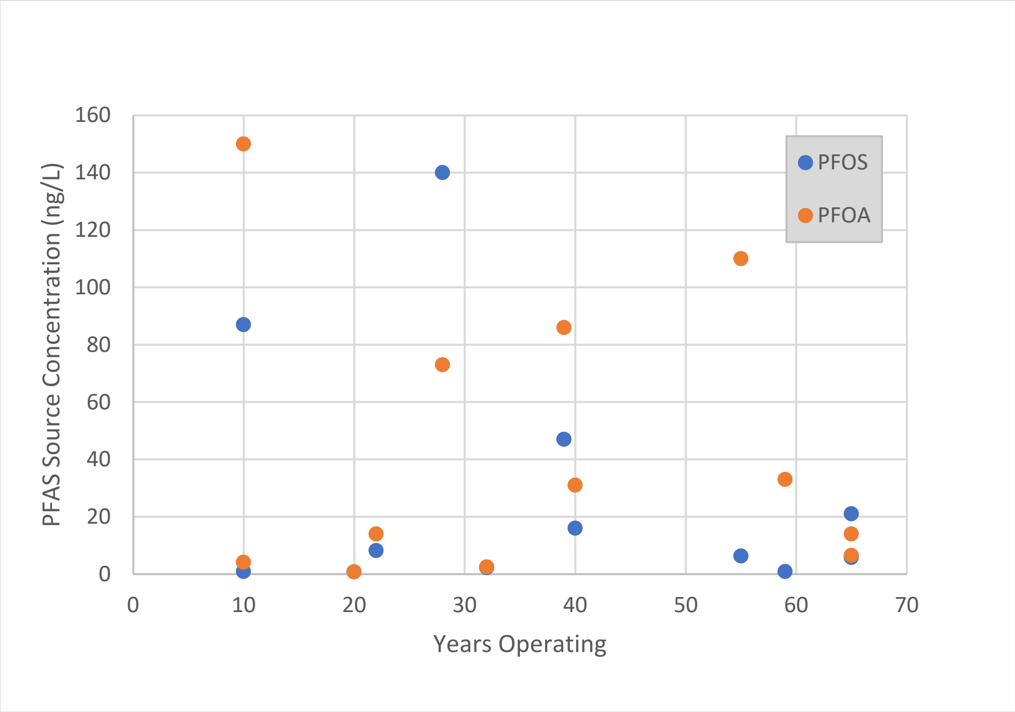
The groundwater data were evaluated with respect to dry-cleaning operational information for the pilot study sites. The following conclusions were drawn based on this evaluation:

- Site DC340039 was a dry-cleaning solvent distribution facility. Virgin solvents were stored at the site; however, no active dry-cleaning operations were conducted, and no waste solvents were stored. The lack of significant PFAS impacts at this site supports the conclusion that PFAS impacts at dry-cleaning facilities are primarily associated with leaching from fabrics during laundering or dry-cleaning processes, and that PFAS is therefore less of a concern at dry-cleaning solvent distribution facilities.
- Site DC920056 operated through the late 1950s, and site DC490007 operated through the 1960s, while PFAS usage in textiles began to become more prevalent in the mid to late 1960s (MPCA, 2023). The lack of significant PFAS impacts at these sites supports the conclusion that PFAS may not be a concern at dry-cleaning facilities that operated prior to the widespread use of PFAS in textiles.
- No clear conclusions could be drawn based on operational information for the remaining sites. Sites in the little evidence, moderate evidence, and strong evidence of PFAS impacts

from dry cleaners categories all operated during the years of widespread PFAS textile use from the 1970s through the 2010s (MPCA, 2023).

An additional evaluation was performed to assess potential correlations between PFAS concentrations and total years of dry cleaner operation. As shown in **Figure 5,** this evaluation did not indicate a significant correlation.

Figure 5 – Graph of PFAS Concentrations Versus Dry Cleaner Operational Timeframe

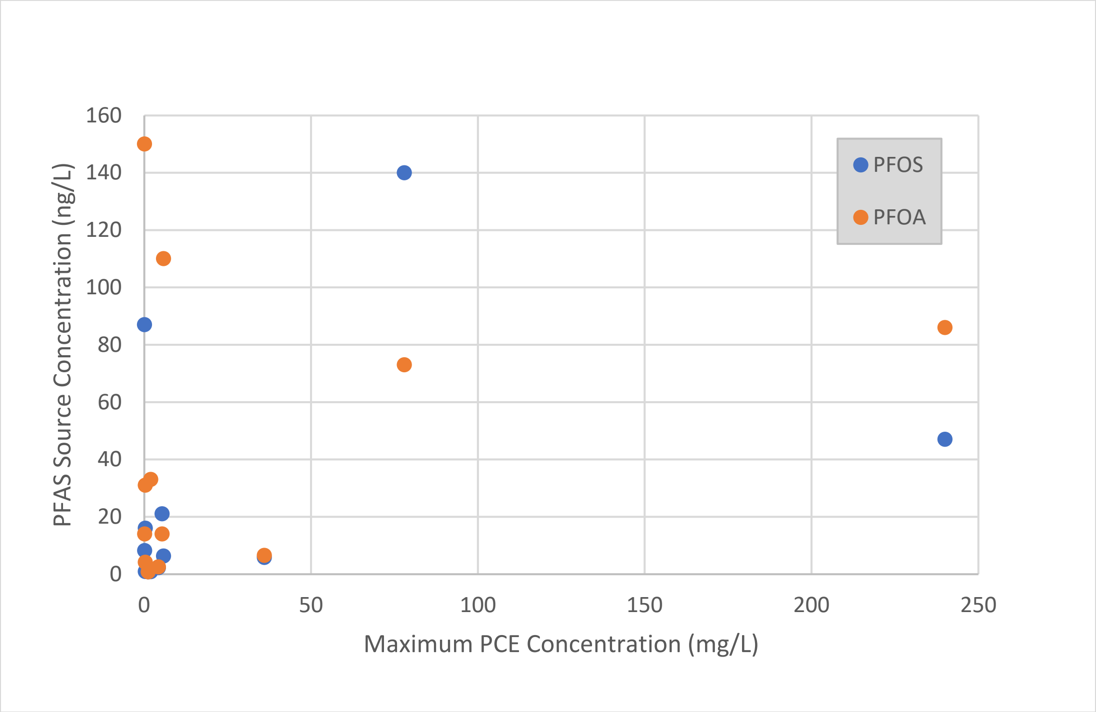


Note:
Data set includes sites in the little, moderate, and strong evidence of PFAS from dry-cleaning operations categories. Sites in the inconclusive category are not included since data for these sites are complicated by potential off-site sources.

6.3.5 PFAS Versus PCE Concentrations

PFAS concentrations were evaluated relative to concentrations of the primary chlorinated dry-cleaning solvent PCE to assess potential correlation. As depicted in **Figure 6**, the results of this evaluation did not indicate a significant correlation. One site was sampled which indicated primarily petroleum dry-cleaning solvent impacts to groundwater with no significant PCE. This site (DC330005) showed significant PFAS detections but is included in the category for sites with inconclusive evidence of PFAS impacts from dry-cleaning operations.

Figure 6 – Graph of PCE Versus PFAS Concentrations



Notes:
Graph indicates maximum detected concentrations of PCE based on historical DSCA assessment data and maximum concentrations of PFOS and PFOA detected in the source well during the pilot study.
Data set includes sites in the little, moderate, and strong evidence of PFAS from dry-cleaning operations categories. Sites in the inconclusive category are not included since data for these sites are complicated by potential off-site sources.

6.3.6 Geographic Variability in PFAS Concentrations

Concentrations of PFAS were evaluated relative to geographic site location to assess potential correlations. Sites were categorized by geologic physiographic province, including the Mountain, Piedmont, Triassic Basin, and Coastal Plain provinces.

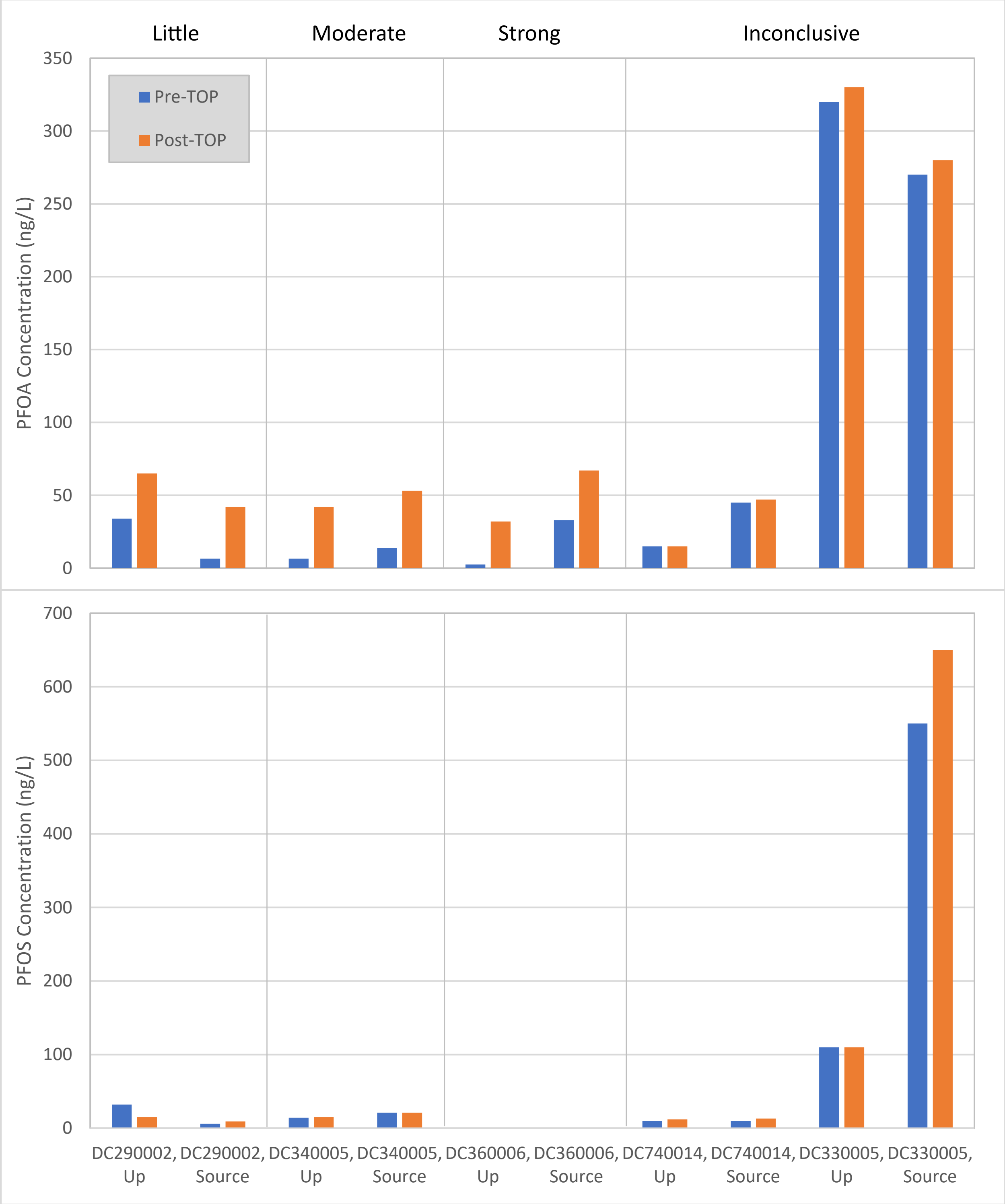
The most notable observation from this evaluation is that the two sites classified as having "inconclusive evidence" of significant PFAS impacts from dry-cleaning operations are the only sites located within the Coastal Plain physiographic province. Site DC330005 is located in Edgecombe County, and site DC740014 is located in Pitt County. At these sites, multiple PFAS were detected at higher concentrations in the upgradient wells versus the dry-cleaning source area wells, although some PFAS were also detected at higher concentrations in the source wells. These sites are outside the area of regional PFAS impacts in eastern North Carolina associated with the Chemours facility in Fayetteville. No confirmed upgradient PFAS sources were identified based on a cursory review of the NCDEQ Laserfiche website; however, the presence of unreported off-site releases cannot be ruled out. Site DC330005 exhibits a low hydraulic gradient, so it is conceivable that the PFAS plume may have spread more in the upgradient direction at this site. Site DC740014 exhibits a more moderate hydraulic gradient, although the upgradient monitoring well is closer to the source area. Additional evaluation would be needed to confirm the source of impacts in the upgradient wells at these sites. Aside from this observation specific to Coastal Plain sites, no clear correlations were identified between PFAS concentrations and geologic region, largely due to the small number of sites evaluated in some physiographic provinces, which limits the ability to draw regional conclusions.

6.3.7 TOP Assay Results

The TOP Assay analysis is designed to identify and estimate concentrations of PFAS precursor compounds that are not fully captured by standard targeted PFAS analyses. TOP Assay testing was performed on a subset of pilot study sites to evaluate the presence of PFAS precursor compounds not fully captured by standard EPA Method 1633 analyses. The method compares PFAS concentrations before and after oxidation to indicate whether precursor compounds are present. The TOP Assay results are complex. For simplicity, this report focuses only on PFOS and PFOA concentrations reported via the TOP Assay. Refer to the separate DSCA Program PFAS Pilot Study Supplemental Report for details regarding the TOP Assay results for other constituents. A summary of the TOP Assay results is provided in **Figure 7** on the following page.

As shown on **Figure 7**, several sites exhibited higher concentrations of PFOS and/or PFOA in the post-TOP samples versus the pre-TOP samples. These data indicate that some precursor compounds were present in the samples with the potential to degrade in the environment into terminal PFAS, such as PFOS and PFOA. However, as discussed further in Section 7.0, TOP analysis of the used solvent samples indicated much higher concentrations of potential precursor compounds. The extent and rate of transformation from precursors to terminal PFAS are influenced by site-specific factors, including redox conditions, microbial activity, geochemical conditions, and the presence of co-contaminants, which collectively affect the rate and extent of precursor degradation (ITRC, 2023). Overall, the pilot study data highlight the complexity of PFAS fate and transport and the likelihood of challenges associated with PFAS data evaluation and interpretation.

Figure 7 – Comparison of Pre- and Post-TOP Assay PFOS and PFOA Groundwater Results



7.0 Process Sample Results and Data Evaluation

The full set of PFAS analytical data for dry-cleaning process samples is included in the DSCA Program PFAS Pilot Study Supplemental Report. The following sections describe the key process sample results and data evaluation.

7.1 Types of Process Samples

Samples identified as "process samples" in this report include virgin solvent, used solvent, the facility's raw water source, post-wet wash water, contact water in the facility mister pre- and post-carbon, spotting agents, detergents, and additives. The specific samples collected varied for each site based on availability and permissions granted by the dry-cleaning business operator. Note that several of the sampled containers were previously opened by dry-cleaning facility staff. Because they were not sealed at the time of sampling, it is possible that the contents may have been altered or mixed with other products and results may not reflect the original formulation. These samples are noted where applicable in this report. In addition, H&H purchased raw PCE solvent, spotting agents, and detergents directly from a dry-cleaning product distributer, FabriClean Supply, and collected samples from these new, unopened containers for evaluation of PFAS. A summary of the types of dry-cleaning process sample types is provided in **Table 7** below.

Table 7 – Summary of Dry-Cleaning Process Sample Types

Sample ID	Sample Description
Virgin dry-cleaning solvent samples	
DC290002-VS	Virgin petroleum solvent - open container
DC-VS	Virgin PCE solvent - new container from distributor
Used dry-cleaning solvent samples	
DC340005-SS	Used PCE solvent (from waste drum)
DC320021-SS	Used PCE solvent (from waste drum)
Pre and post- wet wash laundry water samples	
DC340005-WW-PRE	Wet wash supply water (from bathroom sink)
DC340005-WW-POST	Wet wash spent water (from discharge pipe)
DC340005-WW-BASIN	Wet wash spent water (from discharge basin)
DC320021-WW-PRE	Wet wash supply water
DC320021-WW-Out	Wet wash spent water
920025C-WW-PRE	Wet wash supply water
920025C-WW-POST	Wet wash spent water
DC360006-WW-PRE	Wet wash supply water (from bathroom sink)
DC360006-WW-POST	Wet wash spent water (from discharge basin)
Facility mister samples pre and post-carbon	
DC340005-MIST-PRE	Facility mister water (pre-carbon filter)
DC340005-MIST-POST	Facility mister water (post-carbon filter)
DC320021-Mist-PRE	Facility mister water (pre-carbon filter)
DC320021-Mist-POST	Facility mister water (post-carbon filter)
920025C-Mist-Pre	Facility mister water (pre-carbon filter)
920025C-Mist-Post	Facility mister water (post-carbon filter)
DC360006-MIST-PRE	Facility mister water (pre-carbon filter)

Sample ID	Sample Description
Detergent and additive samples	
DC340005-DET	Detergent A - open container
DC-DET-1	Detergent A - new container from distributor
DC340005-DET-2	Detergent B - open container
DC340005-DET-3	Detergent C - open container
DC320021-DET-1	Detergent D - open container
DC320021-DET-2	Detergent E - open container
920025C-DET-1	Detergent F - open container
920025C-DET-2	Detergent G - open container
DC360006-DET	Detergent H - open container
DC290002-DET	Detergent I - open container
920025C-ADD-1	Additive A - open container
920025C-ADD-2	Additive B - open container
Spotting agent samples	
DC340005-SPOT	Spotting agent A - unopened container at dry cleaner*
DC340005-SPOT-2	Spotting agent B - open container
DC-SPOT-4	Spotting agent B - new container from distributor
920025C-SPOT	Spotting agent C - open container
DC290002-SPOT	Spotting agent D - open container
DC-SPOT-3	Spotting agent D - new container from distributor
DC-SPOT-1	Spotting agent E - new container from distributor
DC-SPOT-2	Spotting agent F - new container from distributor

Notes:
Green shading = new container
Yellow shading = open container
No shading = container type not applicable (i.e., water and waste samples)
* = Sample identified as new container, but note sample was collected from a container at a dry cleaner which appeared to be sealed and previously unopened. Other "new container" samples were purchased from a distributor.

It should be noted that this pilot study did not include sampling related to historical fabric treatment processes (e.g., on-site application of stain- or water-resistant coatings), which were identified through stakeholder discussions as a past practice at some dry-cleaning facilities. As such, potential contributions from these activities are not directly evaluated in this study.

7.2 Data Quality Considerations

The process samples primarily consist of commercial products or heavily impacted waste materials. Based on the nature of the sampled materials, the laboratory conducted pre-extraction screening and diluted the samples before analysis to protect their equipment, which resulted in elevated lab PQLs and MDLs for this data set. As such, in some cases, non-detect results may reflect elevated laboratory detection limits rather than the true absence of PFAS. In addition, the laboratory reported more frequent data flags for this set of samples. In most cases, these data flags indicate that the laboratory was able to determine a reasonable estimated concentration based on the available data. However, due to the nature of the samples, as well as the frequency of data flags and elevated detection limits, the laboratory results for the dry-cleaning process samples are generally considered estimated. No regulatory standards apply to these materials, and analytical precision is considered less critical for these samples for the purposes of the pilot study.

7.3 Dry-cleaning Process Sample Results

The results of the dry-cleaning process sample analyses are discussed in the following sections.

7.3.1 Virgin and Used Solvent Samples

PFAS detected in virgin and used dry-cleaning solvent samples are summarized in **Table 8**. Yellow shading indicates samples collected from open containers, and green shading indicates samples collected from new containers purchased from a distributor.

Table 8 – Summary of PFAS in Virgin and Used Dry-Cleaning Solvent

PFAS COC		Virgin dry-cleaning solvent samples		Used dry-cleaning solvent samples	
		DC290002-VS	DC-VS	DC340005-SS	DC320021 - SS
Long-Chain	PFOA	<1000	<970	25,000	4,900
	PFOS	<1000	<970	1,500	11,000
	PFHxS	<1000	<970	<980	980 J
	PFNA	<1000	<970	1,000	470 J
	PFDA	<1000	<970	5,100	2,000
	PFDS	<1000	<970	<980	450 J
	PFDoA	<1000	<970	2,100	970 J
	PFTeDA	<1000	<970	710 J	370 J
	PFUnA	<1000	<970	370 J	<1000
Short-Chain	HFPO-DA	<1500	<1500	<1500	<1500
	PFBA	<2500	<2400	16,000	2,000 J
	PFBS	<1000	<970	1,800	440 J
	PFPeA	<1000	<970	6,700	500 J
	PFHxA	<1000	<970	57,000	4,700
	PFHpA	<1000	<970	3,100	550 J
Pre-cursors	NEtFOSE	<1500	<1500	23,000	82,000
	NEtFOSAA	<1500	<1500	370 J	350 J
	NMeFOSE	<1500	<1500	12,000	57,000
	8:2 FTS	<1500	<1500	6,100	25,000
Total		ND	ND	162,000	194,000

Notes:
Table only includes PFAS compounds detected at concentrations above lab PQLs.
Concentrations in ng/L or ppt.
"<" values shown are lab PQLs.
J = Concentration above MDL but below lab PQL, refer to the DSCA Program PFAS Pilot Study Supplemental Report for additional data flags associated with depicted concentrations.
ND = Not detected above laboratory MDL.
Green shading = new container; Yellow shading = open container

As shown in **Table 8**, one sample of virgin petroleum solvent (DF-2000) was collected from an open container at a dry-cleaning facility, and one sample of virgin PCE solvent was collected from a new container purchased from a dry-cleaning product distributor. No PFAS were detected in either sample. Two samples of used PCE solvent were collected at two different dry-cleaning facilities. Both samples indicated significantly elevated concentrations of PFOS and PFOA, as well as multiple additional long-chain PFAS, short-chain PFAS, and precursors. A sample of used petroleum solvent was unable to be collected as part of the study.

Overall, the solvent sampling results support the conclusion that PFAS are present in used solvents due to leaching from clothing during the cleaning process, but that PFAS are not significant constituents of the solvents themselves. The data also support the conclusion that used dry-cleaning solvent represents a source of PFAS. Section 7.4 provides additional evaluation of PFAS signatures in used solvent samples in comparison to groundwater samples.

7.3.2 Wet Wash Supply Water and Spent Water

Wet wash operations in this report refer to traditional water-based laundry machines. Samples were collected of wet wash supply water (i.e., water from the facility tap used to fill the machines) and spent wet wash water (i.e., water discharged from the machines after cleaning). PFAS detected in these samples are summarized in **Table 9**.

Table 9 – Summary of PFAS in Pre and Post-Wet Wash Samples

PFAS COC		Pre and post- wet wash laundry water samples								
		Pre	Post	Post	Pre	Post	Pre	Post	Pre	Post
		DC340005-WW-PRE	DC340005-WW-POST	DC340005-WW-BASIN	DC320021 - WW - PRE	DC320021-WW-Out	920025C-WW-Pre	920025C-WW-Post	DC360006-WW-PRE	DC360006-WW-POST
Long-Chain	PFOA	<960	<980	<950	<970	<950	<1000	<930	<990	<950
	PFOS	<960	<980	<950	<970	<950	<1000	<930	<990	<950
Pre-cursors	8:2 FTS	<1400	<1500	<1400	<1500	<1400	960 J	<1400	670 J	<1400
	6:2 FTS	<2400	<2500	<2400	<2400	<2400	<2500	<2300	3,800	<2400
Total		ND	ND	ND	ND	ND	960	ND	4,500	ND

Notes:
Table only includes PFOA, PFOS, and other PFAS compounds detected at concentrations above lab PQLs.
Concentrations in ng/L or ppt.
"<" values shown are lab PQLs.
J = Concentration above MDL but below lab PQL, refer to the DSCA Program PFAS Pilot Study Supplemental Report for additional data flags associated with depicted concentrations.
ND = Not detected above laboratory MDL.

PFAS precursors were detected in two of the wet wash supply water samples, but no PFAS were detected in the spent wet wash water samples. As previously referenced, lab PQLs for this data set were elevated. The FDEP Study identified generally higher concentrations of PFAS in wet wash spent water versus supply water, suggesting that PFAS may leach from clothing during wet wash operations in addition to dry-cleaning operations. However, concentrations reported in spent wet wash samples in the FDEP study were significantly lower than those detected in used solvent samples. The elevated lab PQLs for the NC pilot study data set may mask this effect. Overall, while wet wash operations cannot be ruled out as a potential PFAS source, the data indicate that used dry-cleaning solvent is likely a more significant potential source of PFAS impacts at dry-cleaning sites than spent wet wash water.

7.3.3 Mister Water Samples

Misters are commonly used at dry-cleaning facilities to manage contact water generated during dry-cleaning operations. Misters typically incorporate internal carbon filters which are used to treat the contact water, then the unit disperses the liquid as a fine aerosol or mist into the ambient air. Samples were collected of water in the misters before and after carbon filters. PFAS detected in these samples are summarized in **Table 10**.

Table 10 – Summary of PFAS in Pre and Post-Wet Carbon Mister Samples

PFAS COC		Facility mister samples pre and post-carbon						
		Pre	Post	Pre	Post	Pre	Post	Pre
		DC340005-MIST-PRE	DC340005-MIST-POST	DC320021 - Mist - PRE	DC320021 - Mist - POST	920025C-Mist-Pre	920025C-Mist-Post	DC360006-MIST-PRE
Long-Chain	PFOA	570 J	<980	770 J	660 J	<970	<990	<970
	PFOS	<940	<980	<930	<990	<970	<990	<970
Short-Chain	PFHxA	710 J	<980	750 J	590 J	<970	<990	<970
Precursors	PFOSA	660 J	<980	<930	<990	<970	<990	<970
	8:2 FTS	<1400	<1500	<1400	<1500	<1500	2,400 EB	<1500
Total		1,940	ND	1,520	1,250	ND	2,400	ND

Notes:
Table only includes PFOA, PFOS, and other PFAS compounds at concentrations above lab PQLs.
Concentrations in ng/L or ppt.
"<" values shown are lab PQLs.
J = Concentration above MDL but below lab PQL, refer to the DSCA Program PFAS Pilot Study Supplemental Report for additional data flags associated with depicted concentrations.
ND = Not detected above laboratory MDL.
EB = Constituent detected in associated equipment blank

PFOA and PFHxA were detected at laboratory-estimated concentrations in post-carbon samples at one site. 8:2 FTS was also detected in the post-carbon sample at a separate site; however, this compound was also detected in the associated equipment blank, indicating that the detection may be attributable to sample contamination. The date of the last carbon changeout at each facility was not confirmed. Additional mister sampling and evaluation of carbon changeout dates are considered warranted prior to making significant conclusions regarding PFAS in contact water and alternative management approaches.

7.3.4 Spotting Agents, Detergents, and Additive Samples

Samples were collected from six spotting agents, nine detergents, and two additives. As previously discussed, the majority of the samples were collected from containers that had been previously opened and used at dry-cleaning facilities. Because the contents of these containers cannot be reasonably verified, specific manufacturer names are not referred to in this report; instead, products are identified generically as A, B, C, etc. In a few cases, products were resampled by purchasing new containers directly from a dry-cleaning product distributor. PFAS detected in these samples are summarized in **Table 11**.

Table 11 – Summary of PFAS in Spotting Agent, Detergent, and Additive Samples

PFAS COC		Spotting agent samples							
		Spotting agent A	Spotting agent B	Spotting agent B	Spotting agent C	Spotting agent D	Spotting agent D	Spotting agent E	Spotting agent F
		DC340005-SPOT*	DC340005-SPOT-2	DC-SPOT-4	920025C-SPOT	DC290002-SPOT	DC-SPOT-3	DC-SPOT-1	DC-SPOT-2
Long-Chain	PFOA	340 J	<990	<9600	<960	1,800,000	<9500	<980	<950
	PFOS	<970	<990	<9600	<960	<930	<9500	<980	<950
	PFNA	<970	<990	<9600	<960	57,000	<9500	<980	<950
	PFDA	<970	<990	<9600	<960	300,000	<9500	<980	<950
	PFDoA	<970	<990	<9600	<960	120,000	<9500	<980	<950
	PFTeDA	<970	<990	<9600	<960	42,000	<9500	<980	<950
	PFTrDA	<970	<990	<9600	<960	4,000	<9500	<980	<950
	PFUnA	<970	<990	<9600	<960	15,000	<9500	<980	<950
Short-Chain	HFPO-DA	<1500	6,800	<14000	<1400	<1400	<14000	<1500	<1400
	PFBA	2,600	<2500	<24000	<2400	210,000	<24000	1,300 J	<2400
	PFPeA	560 J	<990	<9600	<960	82,000	<9500	<980	<950
	PFHxA	470 J	<990	<9600	<960	650,000	<9500	<980	<950
	PFHpA	310 J	510 J	<9600	<960	110,000	<9500	<980	<950
Pre-cursors	8:2 FTS	<1500	<1500	<14000	<1400	540 J	<14000	<1500	<1400
	7:3 FTCA	<970	<990	<9600	<960	60,000	<9500	<980	<950
	5:3 FTCA	<970	<990	<9600	<960	1,700	<9500	<980	<950
	3:3 FTCA	<970	<990	<9600	<960	200 J	<9500	<980	<950
Total		4,300	7,300	ND	ND	3,500,000	ND	1,300	ND

PFAS COC		Detergent and additive samples											
		Det A	Det A	Det B	Det C	Det D	Det E	Det F	Det G	Det H	Det I	Add A	Add B
		DC340005-DET	DC-DET-1	DC340005-DET-2	DC340005-DET-3	DC320021 - DET - 1	DC320021 - DET - 2	920025C-DET-1	920025C-DET-2	DC360006-DET	DC290002-DET	920025C-ADD-1	920025C-ADD-2
Long-Chain	PFOA	17,000	<9700	3,100	<970	<960	<980	<990	<950	<0.57	2.4	<950	<980
	PFOS	<950	<9700	<940	<970	<960	<980	<990	<950	<0.57	<0.59	<950	<980
	PFNA	1,500	<9700	<940	<970	<960	<980	<990	<950	<0.57	<0.59	<950	<980
	PFDA	10,000	<9700	<940	<970	<960	<980	<990	<950	<0.57	1.6	<950	<980
	PFDoA	4,800	<9700	<940	<970	<960	<980	<990	<950	<0.57	<0.59	<950	<980
	PFTeDA	1,500	<9700	<940	<970	<960	<980	<990	<950	<0.57	<0.59	<950	<980
Short-Chain	HFPO-DA	1,200 J	<15000	<1400	<1500	<1400	<1500	<1500	<1400	<1.9	<2.0	<1400	<1500
	PFHxA	33,000	<9700	<940	<970	<960	<980	<990	<950	<0.57	1.9	<950	<980
	PFHpA	1,500	<9700	<940	<970	<960	<980	<990	<950	<0.57	<0.59	<950	<980
Pre-cursors	PFOSA	<950	<9700	1,500	<970	<960	<980	<990	<950	<0.57	<0.59	<950	<980
	NMeFOSE	<1400	<15000	<1400	<1500	<1400	34,000	<1500	<1400	<1.9	<2.0	<1400	<1500
	6:2 FTS	<2400	<24000	<2400	<2400	<2400	<2500	<2500	4,300	<1.9	<2.0	<2400	<2500
Total		71,000	ND	4,600	ND	ND	34,000	ND	4,300	ND	2.4	ND	ND

Notes:
Table only includes PFOS, PFOA, and other PFAS compounds detected at concentrations above PQLs.
Concentrations in ng/L.
"<" values shown are lab PQLs; ND = Not detected above laboratory MDL.
J = Concentration above MDL but below PQL, refer to the DSCA Program PFAS Pilot Study Supplemental Report for additional data flags associated with depicted concentrations.
Green shading = new container; Yellow shading = open container, * = Sample was collected at a dry cleaner from a "new" container which appeared to be sealed and previously unopened. Other "new container" samples were purchased from a distributor.

Key findings from sampling of spotting agents, detergents, and additives are summarized below.

- A sample of Spotting Agent D collected from an open container at a dry-cleaning facility exhibited the highest PFOA concentration detected study-wide, at 1,800,000 ng/L, in addition to numerous other short-chain PFAS, long-chain PFAS, and PFAS precursors. However, a sample of Spotting Agent D ordered directly from a dry-cleaning product distributor indicated no detections.
- A sample of Spotting Agent Sample B collected from an open container at a dry-cleaning facility indicated a detectable concentration of HFPO-DA (i.e., GenX) at 6,800 ng/L. However, a corresponding sample of Spotting Agent B ordered directly from a dry-cleaning product distributor exhibited no PFAS detections.
- A sample of Spotting Agent A collected from a container at a dry cleaner that appeared to be new and unopened indicated an estimated concentration of PFOA at 340 ng/L, in addition to several other short-chain PFAS. Because this product was not purchased directly from the distributor, the contents cannot be fully verified, although the container appeared to be unopened at the time of sampling. The age of the container also could not be verified, so it is possible that the sample reflects an older formulation.
- No PFAS were detected in samples collected from products purchased directly from dry-cleaning product distributors, other than a laboratory-estimated concentration of PFBA in Spotting Agent E. PFBA is a common short-chain replacement chemical.
- Multiple PFAS were detected in samples collected from other open containers at dry-cleaning facilities; however, it is unclear whether these detections reflect the original product formulation or alterations resulting from onsite handling practices.

Overall, the results of sampling from recent containers purchased directly from the distributor indicated no PFAS above lab PQLs. Based on discussions with local dry cleaners, it is common practice to mix different product formulations during cleaning operations. Discrepancies in concentrations could be attributed to this practice, or the sampled formulations may be aged and represent purchases prior to more recent PFAS phase outs. The representativeness of samples collected from previously opened containers at dry-cleaning facilities is uncertain. However, the data from open containers remain useful, as they reflect the products and use practices currently employed by some dry-cleaning facilities. It should also be noted that these products are typically used in relatively small quantities at dry-cleaning facilities and therefore represent a lower-magnitude potential PFAS source compared to dry-cleaning solvents.

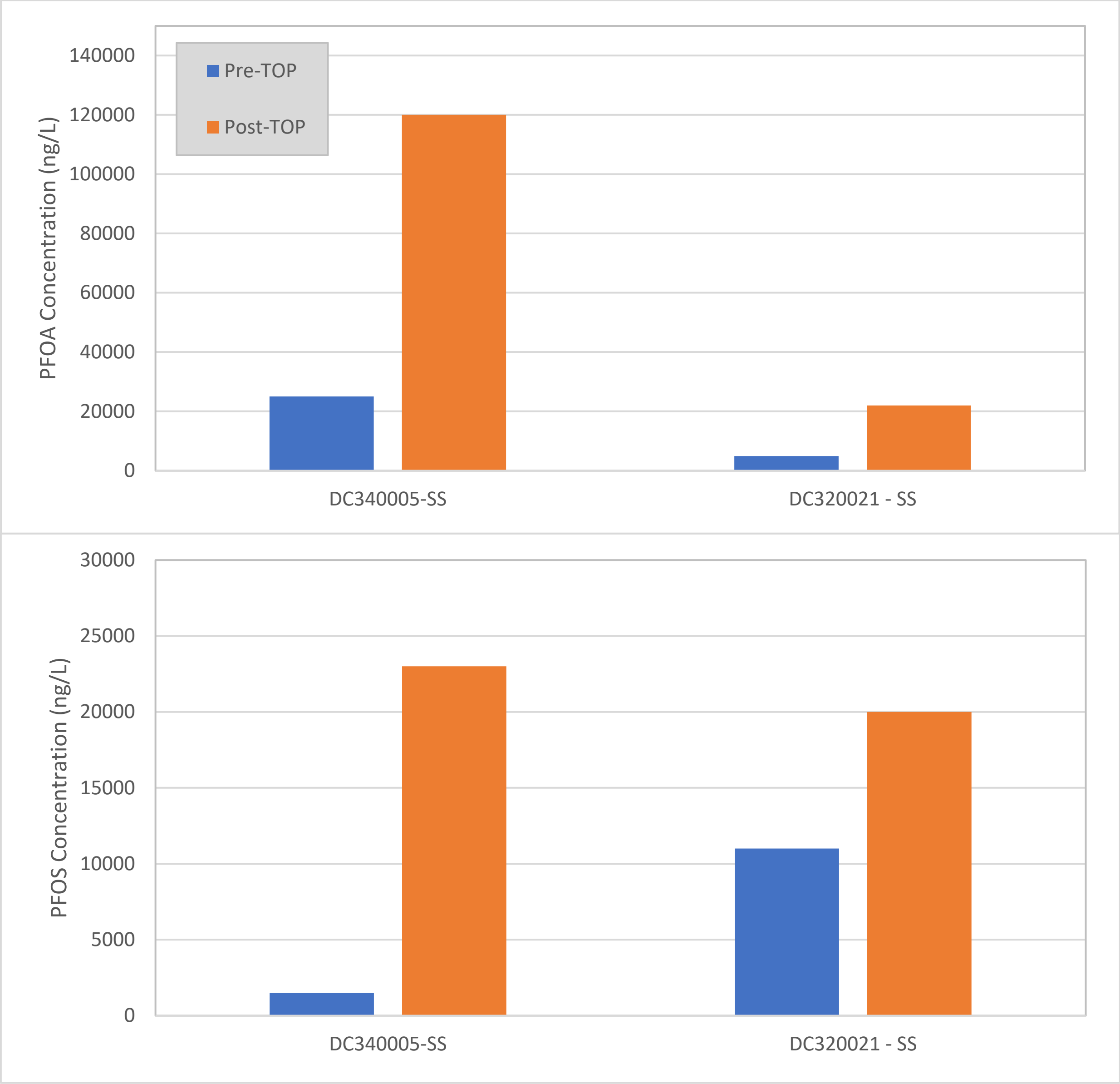
7.3.5 Used Solvent Sample Signatures

The NCDEQ PFAS Signature Tool was used to create pie charts for the used solvent samples, which are included in **Attachment 2**. The used solvent samples were the primary focus of the signature evaluation because the pilot study data suggest that used solvent is a key potential source of PFAS impacts to groundwater. The most notable conclusion based on review of the graphs for used PCE solvent versus groundwater samples is that the solvent contains significantly higher concentrations of PFAS precursors. This is further corroborated by the TOP Assay data discussed in Section 7.3.6. Lower concentrations of precursors and higher concentrations of terminal PFAS in groundwater likely reflect degradation of PFAS in the environment.

7.3.6 TOP Assay Results

As referenced in Section 6.3.7, the TOP Assay compares PFAS concentrations before and after oxidation to estimate concentrations of PFAS precursor compounds that are not fully captured by standard targeted PFAS analyses. The majority of the dry-cleaning process samples were analyzed using TOP methodology in order to evaluate for precursor PFAS. Overall, data interpretation for these samples is challenging. For simplicity, this report focuses only on TOP Assay results for the used solvent samples, since used solvent was identified as a potential source of PFAS impacts. A summary of the TOP Assay results is provided in **Figure 8**.

Figure 8 – Comparison of Pre- and Post-TOP Assay PFOS and PFOA Used Solvent Results



As shown on **Figure 8**, concentrations of PFOS and PFOA were significantly higher in the post-TOP used solvent samples versus the pre-TOP samples. These data indicate that significant precursor compounds were present in the samples with the potential to degrade in the environment into terminal PFAS, such as PFOS and PFOA. These data are consistent with the standard EPA Method 537 results which also showed significant detectable precursor compounds in the used solvent samples.

8.0 Pilot Study Conclusions

Key conclusions identified based on the DSCA PFAS pilot study results are summarized below:

- Dry-cleaning facilities are often located in highly populated, developed areas, and PFOS and/or PFOA were detected in upgradient monitoring wells above lab PQLs at all 14 sites and above NC 2L Standards (equivalent to EPA PQL) at nine of the 14 sites.. These findings confirm that PFAS are commonly present in background groundwater and that **determination of background concentrations is an important component of PFAS assessment at dry-cleaning sites**.
- The results of the pilot study indicate **little evidence of PFAS impacts at 36% of sites, moderate or strong evidence of PFAS impacts at 50% of sites, and inconclusive evidence at 14% of sites**. Assuming the pilot sites are generally representative of the DSCA Program site inventory, these results may help provide context regarding the potential scope of future PFAS assessment efforts across the DSCA Program.
- PFOS and PFOA are among the most widely studied PFAS, have established NC 2L Standards and EPA MCLs, and are generally considered to pose a greater potential human health concern relative to many other PFAS. In groundwater samples, PFOA was the most frequently detected PFAS at concentrations significantly above background and was the highest-concentration PFAS at four of the seven sites with moderate or strong evidence of PFAS impacts from dry-cleaning operations. PFOS was detected less frequently at concentrations significantly above background, but was the highest-concentration PFAS at two of the seven sites. These data suggest that **PFOS and/or PFOA are key PFAS COCs for most dry-cleaning sites. Various other PFAS were detected; however, other than the predominance of PFOS and/or PFOA, review of the pilot test data did not suggest a specific PFAS signature for dry-cleaning sites.**
- Concentrations of PFOS and PFOA detected at the NC pilot study sites were generally around two orders of magnitude lower than mean concentrations for primary-source sites, such as fire training areas and manufacturing plants. These data suggest that **dry cleaners represent a less significant source of PFAS in the environment in comparison to primary-source sites**.
- No significant PFAS were detected in groundwater samples collected at the one dry-cleaning solvent distribution facility, where virgin solvents were stored but no active dry-cleaning operations were conducted and no waste solvents were stored. The lack of significant PFAS impacts at this site supports the conclusion that **PFAS impacts are less of a concern at dry-cleaning solvent distribution facilities where no active dry-cleaning operations were conducted.**
- No significant PFAS were detected at the two sites that operated through the 1950s or 1960s. These data support the conclusion that **PFAS is less of a concern at sites that operated before PFAS usage in textiles began to become more prevalent in the mid to late 1960s**.

- Evaluation of PFAS concentrations in groundwater relative to geographic site location notably indicated that the two sites identified as having "inconclusive evidence" of significant PFAS impacts from dry-cleaning operations are the only sites located within the Coastal Plain physiographic province. Data evaluation for these sites could be complicated by off-site sources, increased upgradient PFAS migration due to low hydraulic gradients, or other factors. **Other than inconclusive data for the two sites in the Coastal Plain, no other clear correlations between PFAS concentrations and geographic region were identified.**

- Evaluation of PFAS concentration in groundwater relative to PCE concentrations did not indicate a significant correlation; demonstrating that **PCE concentrations are not a reliable predictor of PFAS concentrations at dry-cleaning sites**.

- Virgin PCE and petroleum solvent samples showed no detectable PFAS; however, used PCE solvent samples indicated significantly elevated concentrations of multiple PFAS. These findings support the conclusion that **PFAS are present in used solvents due to leaching from clothing during the cleaning process, but that PFAS are not significant constituents of the solvents themselves.** Note that used petroleum solvent samples were not collected as part of the pilot study but would be a useful future data collection component.

- No PFAS were detected in spent wet wash water samples. It is possible that elevated lab PQLs may mask low-level contributions; however, the data generally suggest that **used dry-cleaning solvent is likely a more significant potential source of PFAS impacts at dry-cleaning sites as opposed to spent wet wash water.**

- Sampling of contact water associated with facility misters indicated laboratory-estimated concentrations in some pre- and post-carbon samples. The date of the last carbon changeout at each facility was not confirmed. **Additional sampling and evaluation of mister carbon changeout dates is considered warranted prior to making significant conclusions regarding PFAS in contact water and alternative management approaches.**

- Sampling of spotting agents, detergents, and additives from containers already opened at dry cleaner facilities indicated significant PFAS concentrations. However, sampling from new, unopened containers purchased directly from a distributor indicated no PFAS above lab PQLs. Based on discussions with local dry cleaners, it is common practice to mix different product formulations during cleaning operations. The age of the formulations in previously opened containers is also unclear. As a result, **the representativeness of samples collected from previously opened containers at dry-cleaning facilities is uncertain. Regardless, these products are typically used in relatively small quantities and therefore represent a lower-magnitude potential PFAS source compared to spent dry-cleaning solvents.**

- Standard laboratory analyses of groundwater samples indicated only negligible detections of PFAS precursor compounds. However, significant concentrations of precursor compounds were detected in used PCE solvent samples. In addition, TOP Assay results from selected samples identified substantial precursor contributions in both groundwater and used solvent samples that were not captured by standard analytical methods. **These**

findings indicate that PFAS precursors are an important consideration in the evaluation of dry-cleaning sites and underscore the complexity of PFAS fate and transport, as well as the likelihood of challenges associated with PFAS data evaluation and interpretation.

9.0 References

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- Eurofins Lancaster Laboratories Environment Testing, LLC

DRAFT

Attachment 1

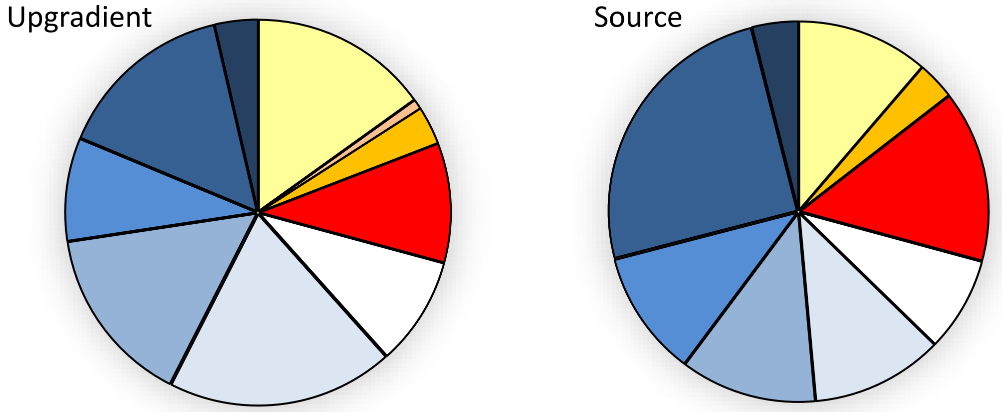
Pilot Study Groundwater Sampling

Site Maps and Graphs

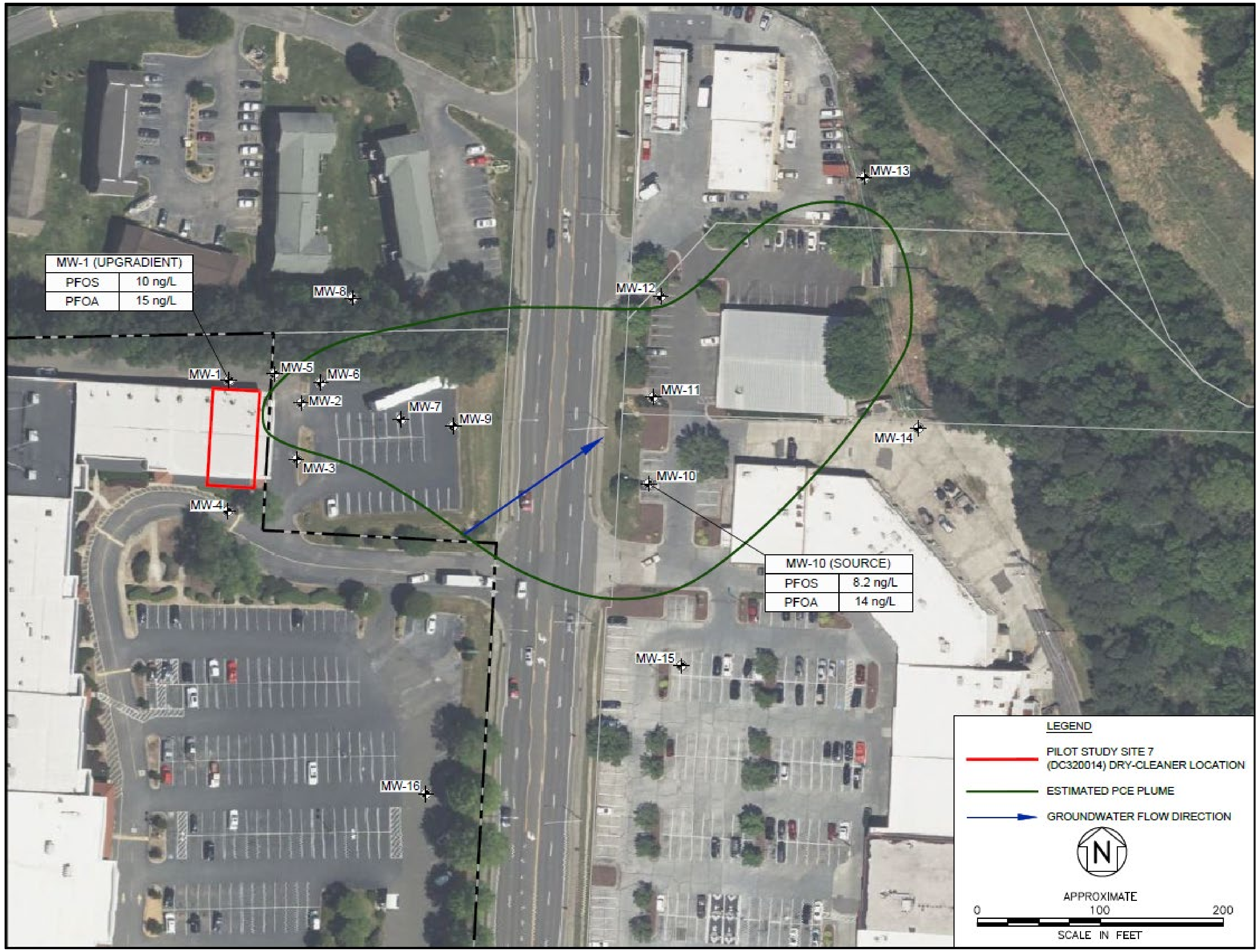
LITTLE EVIDENCE

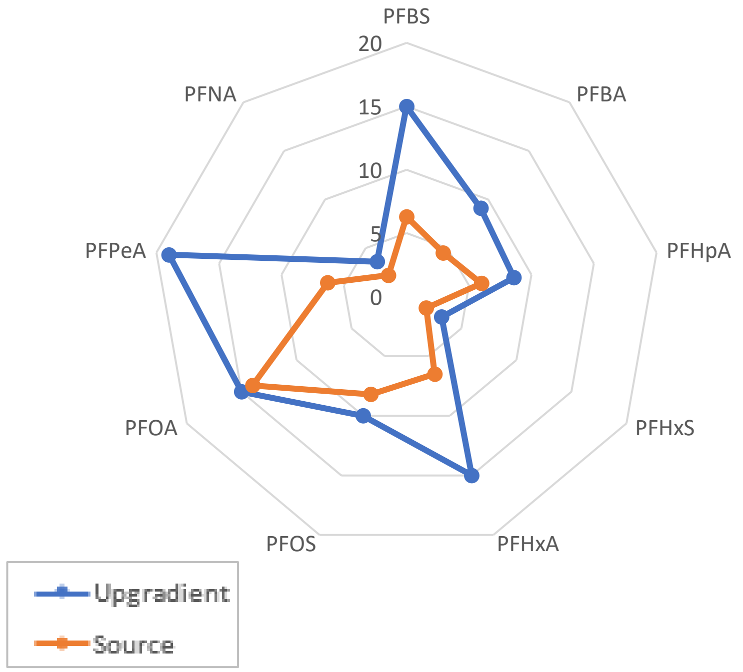
DSCA PFAS Pilot Study
Site DC320014
Site Category: Little evidence of PFAS impacts from dry-cleaning operations

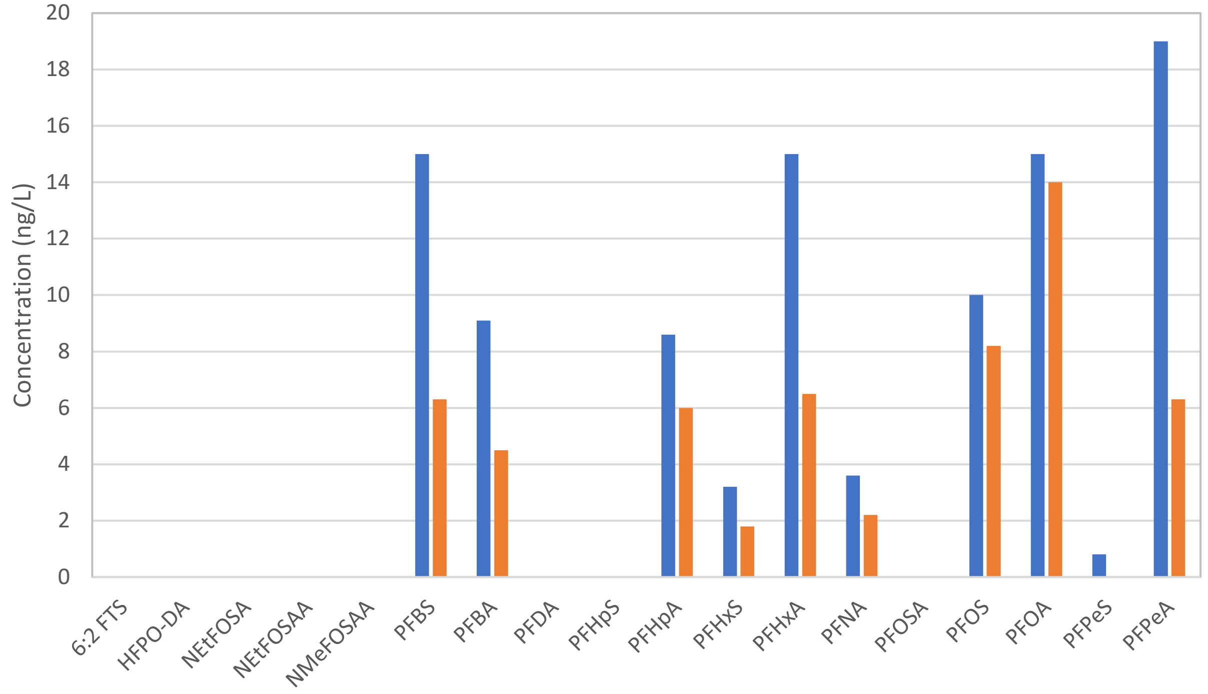
Note that graphs include:
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).



- ☐ PFBS
- ☐ PFPeS
- ☐ PFHxS
- ☐ PFHpS
- ☐ PFOS
- ☐ PFBA
- ☐ PFPeA
- ☐ PFHxA
- ☐ PFHpA
- ☐ PFOA
- ☐ PFNA
- ☐ PFDA
- ☐ 6:2 FTS
- ☐ PFOSA
- ☐ NEtFOSA
- ☐ NMeFOSAA
- ☐ NEtFOSAA
- ☐ HFPO-DA (GenX)



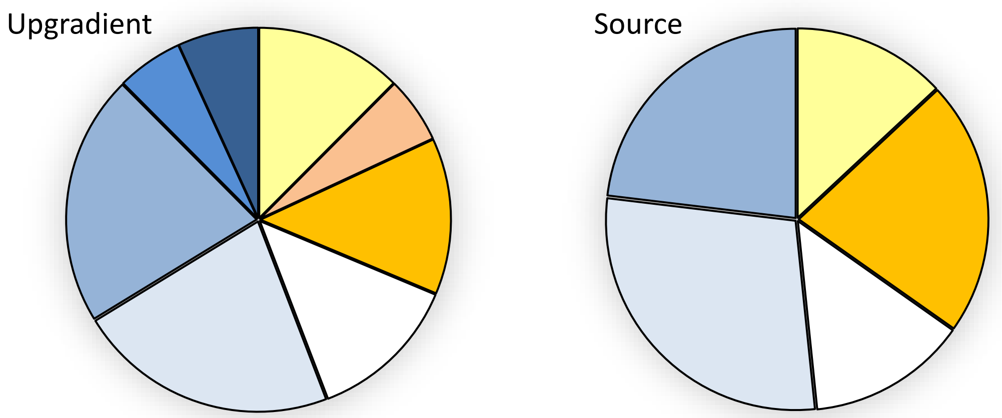




LITTLE EVIDENCE

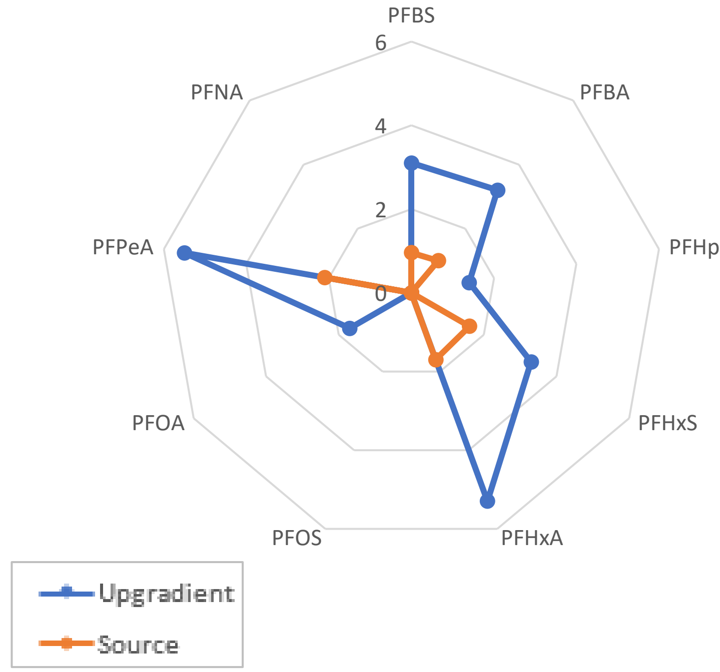
DSCA PFAS Pilot Study
Site DC490007
Site Category: Little evidence of PFAS impacts from dry-cleaning operations

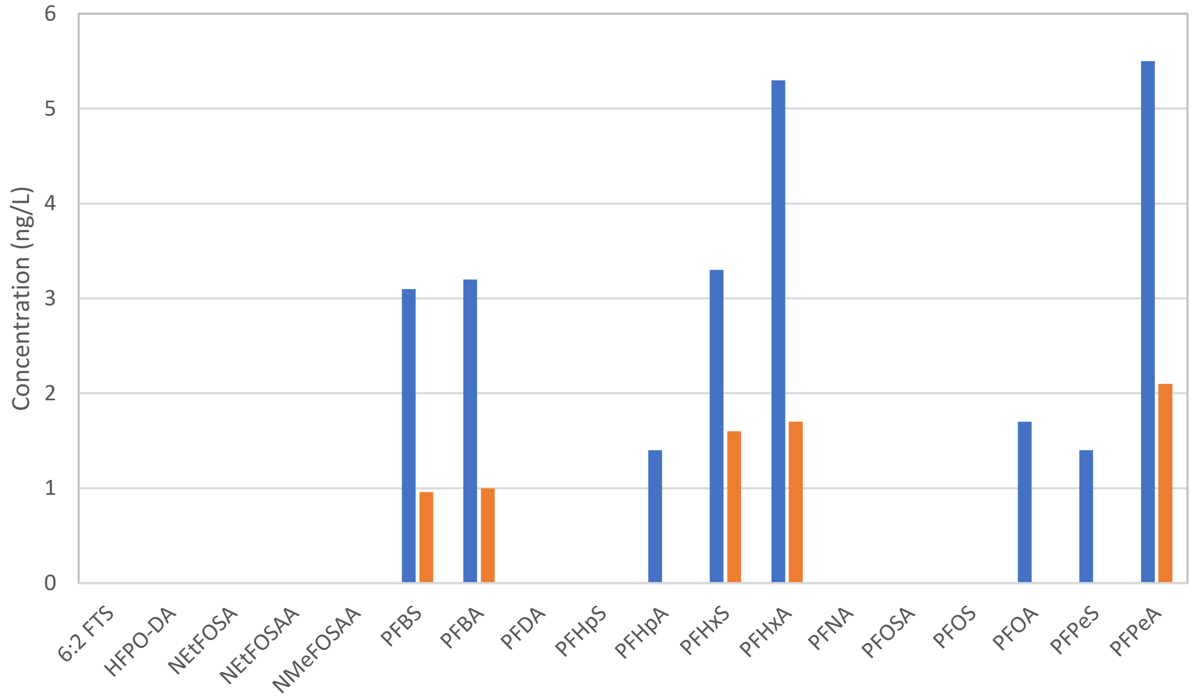
Note that graphs include:
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).



MW-1 (SOURCE)	
PFOS	<1.5 ng/L
PFOA	<1.5 ng/L

MW-3 (UPGRADIENT)	
PFOS	<1.5 ng/L
PFOA	1.7 ng/L

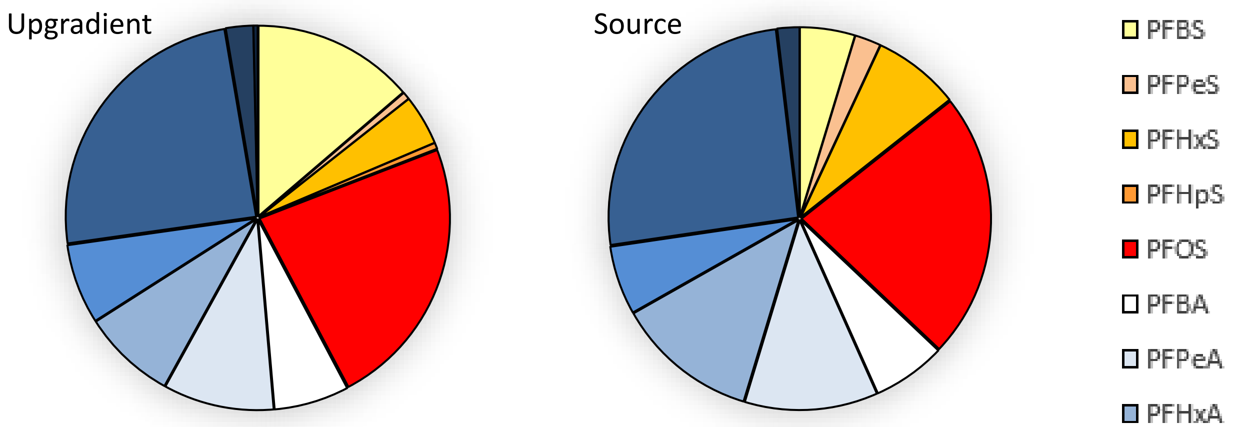


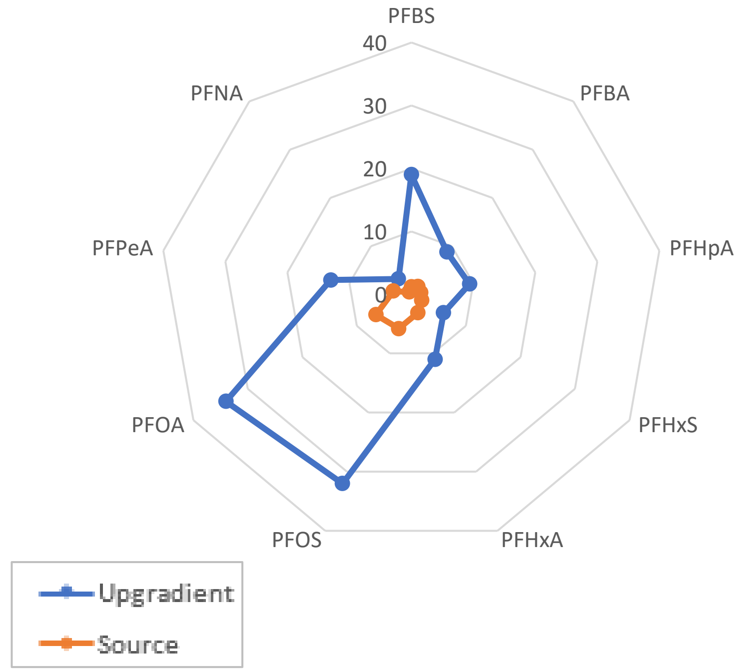


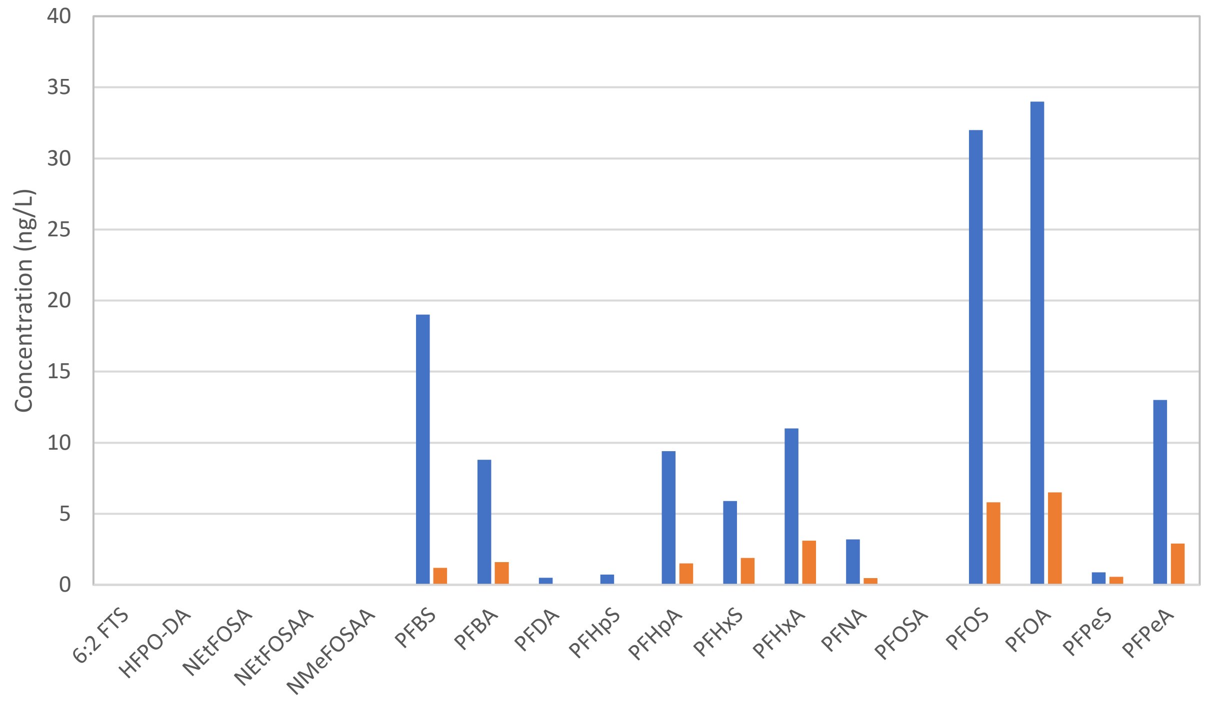
LITTLE EVIDENCE

DSCA PFAS Pilot Study
Site DC290002
Site Category: Little evidence of PFAS impacts from dry-cleaning operations

Note that graphs include:
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).





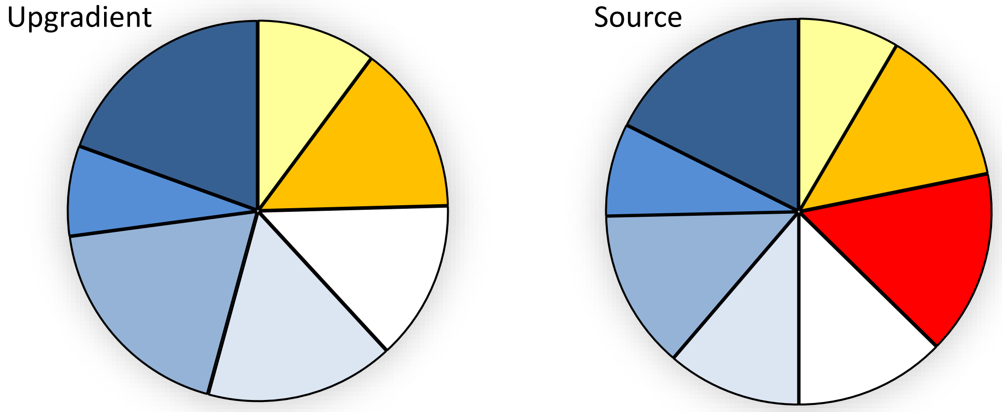


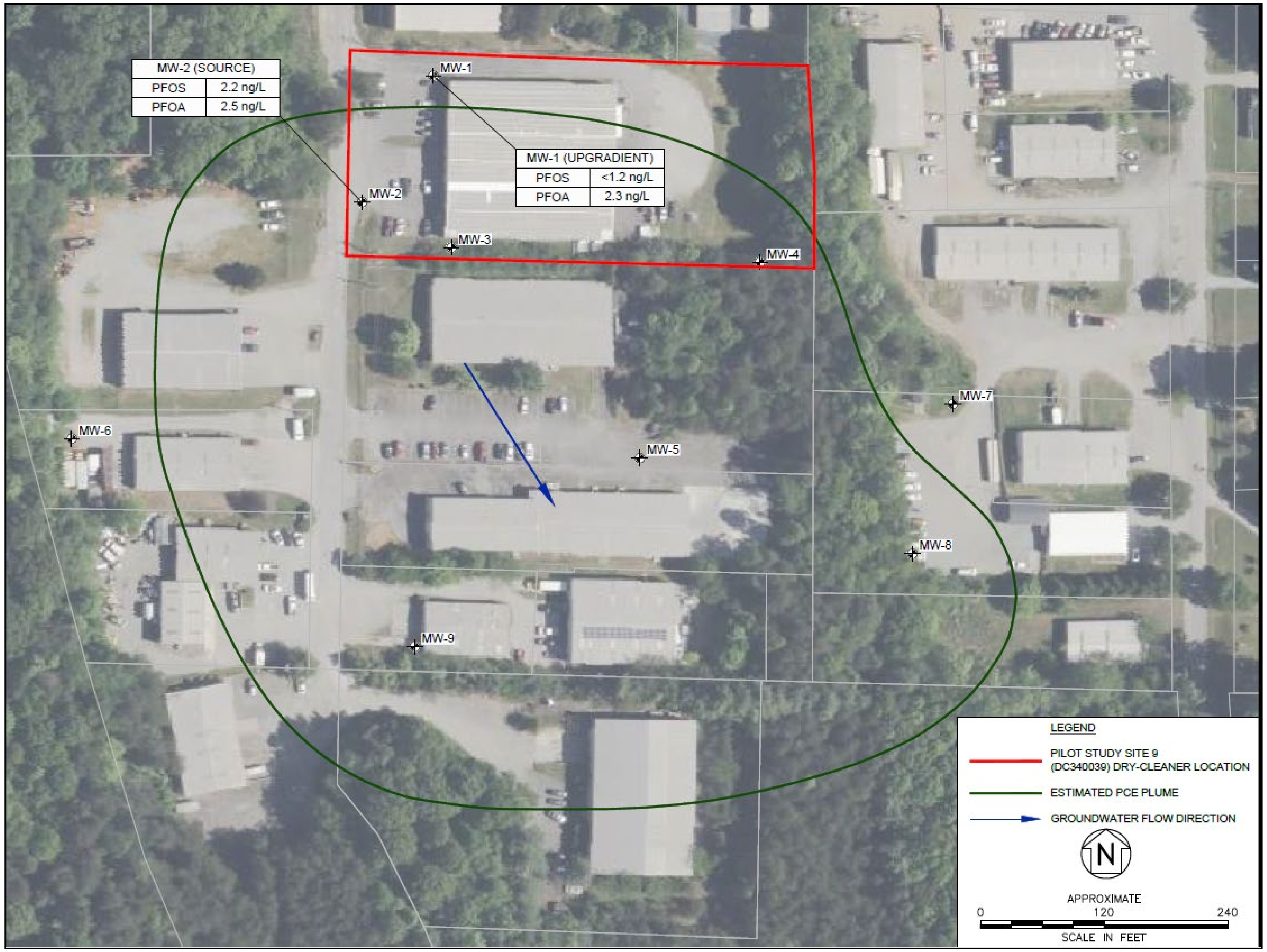
LITTLE EVIDENCE

DSCA PFAS Pilot Study
Site DC340039
Site Category: Little evidence of PFAS impacts from dry-cleaning operations

Note that graphs include:

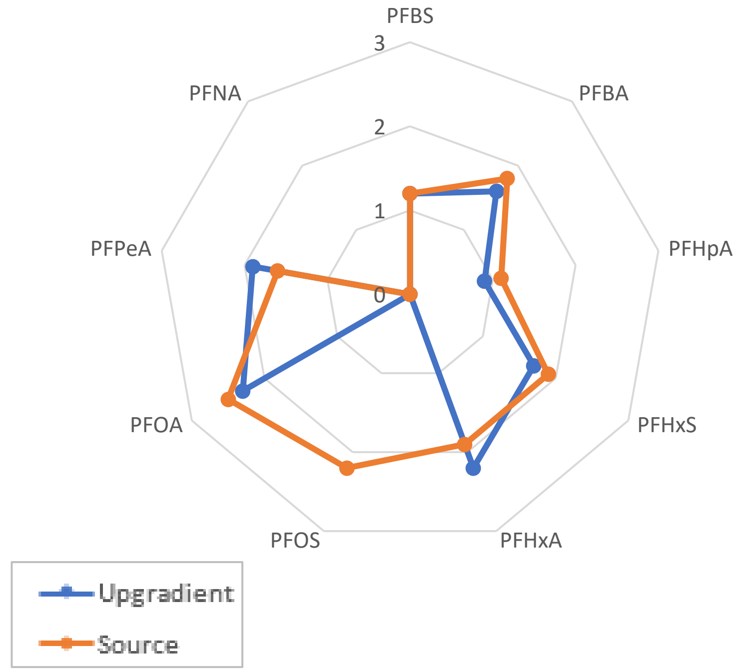
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).

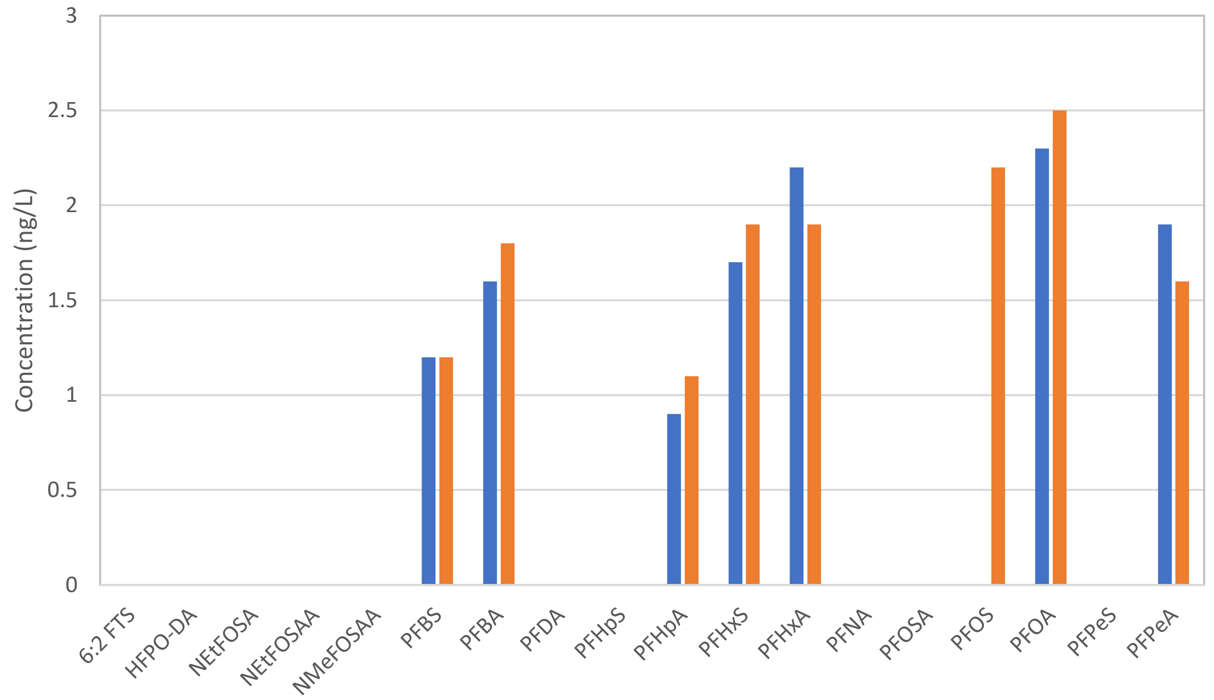




MW-2 (SOURCE)	
PFOS	2.2 ng/L
PFOA	2.5 ng/L

MW-1 (UPGRADIENT)	
PFOS	<1.2 ng/L
PFOA	2.3 ng/L

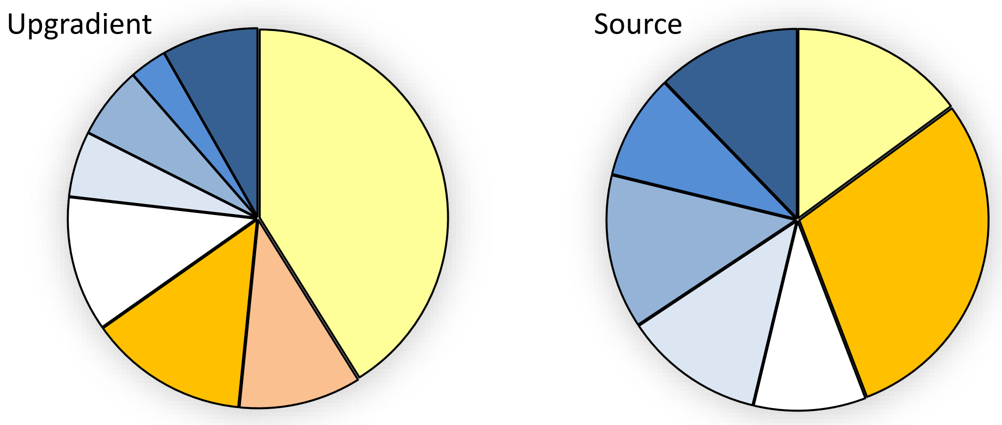




LITTLE EVIDENCE

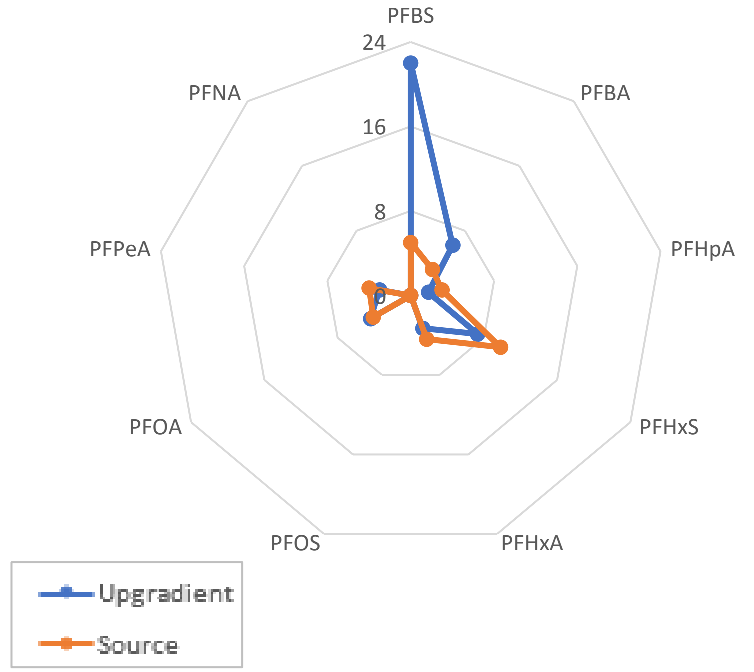
DSCA PFAS Pilot Study
Site DC920056
Site Category: Little evidence of PFAS impacts from dry-cleaning operations

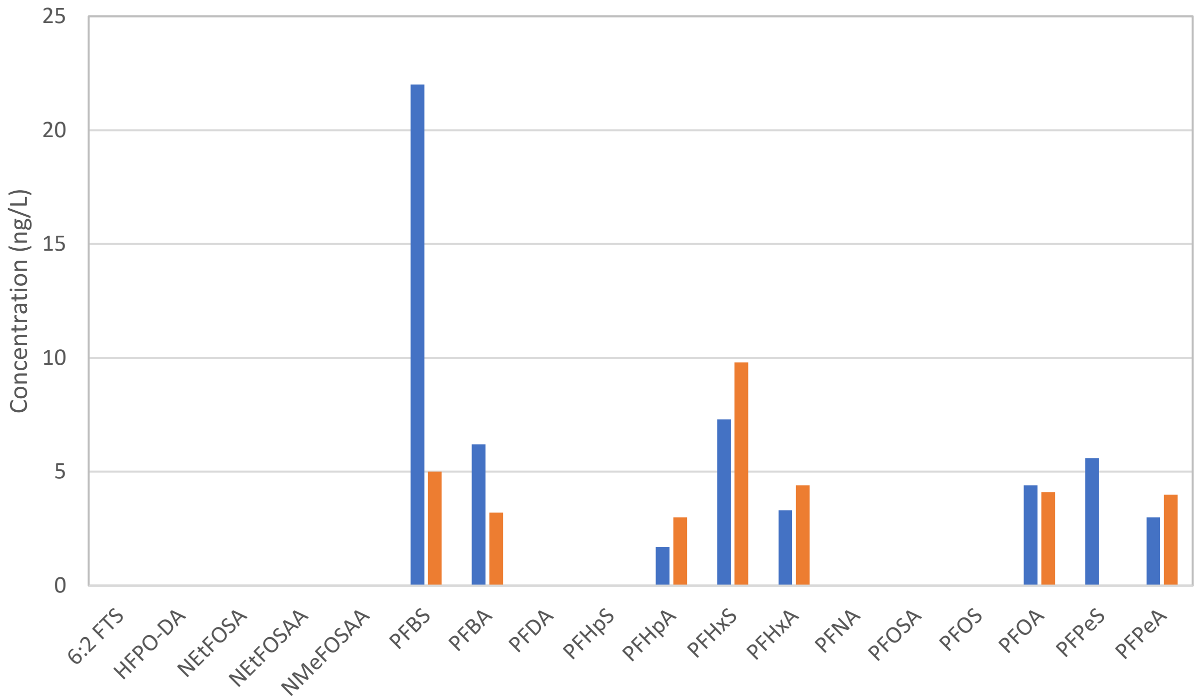
Note that graphs include:
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).



MW-1 (SOURCE)	
PFOS	<1.8 ng/L
PFOA	4.1 ng/L

MW-3 (UPGRADIENT)	
PFOS	<1.7 ng/L
PFOA	4.4 ng/L

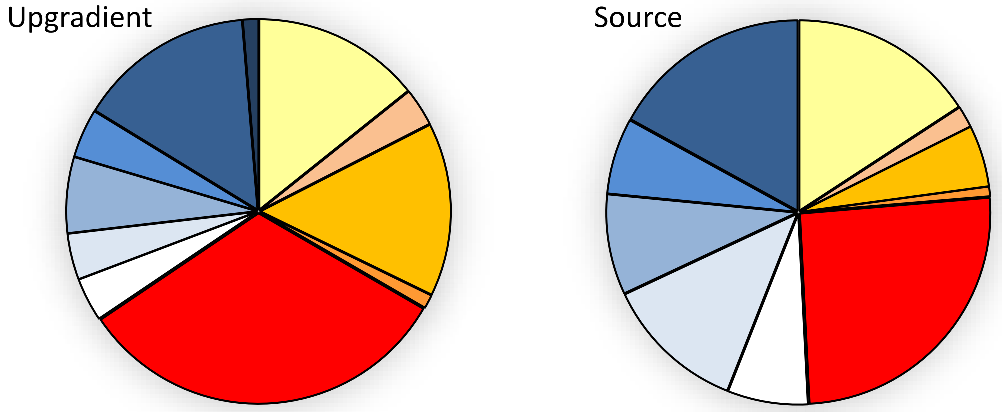


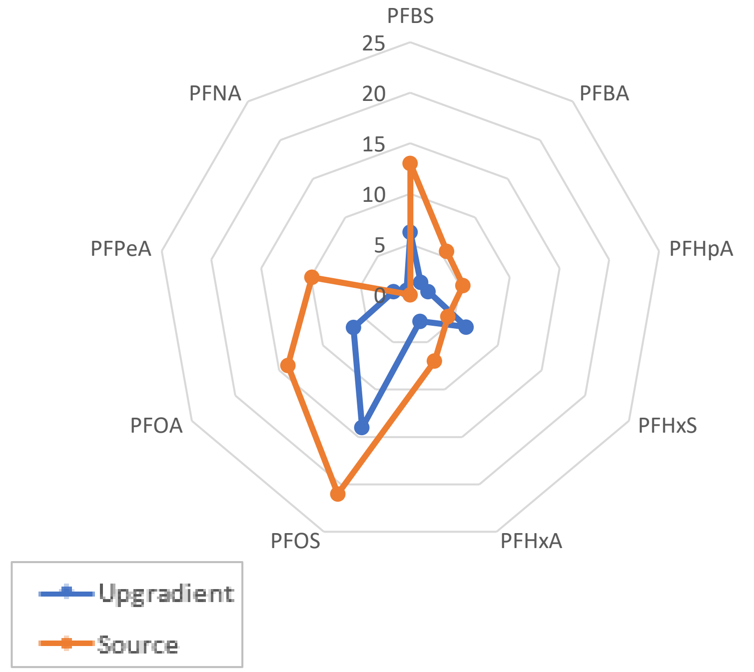


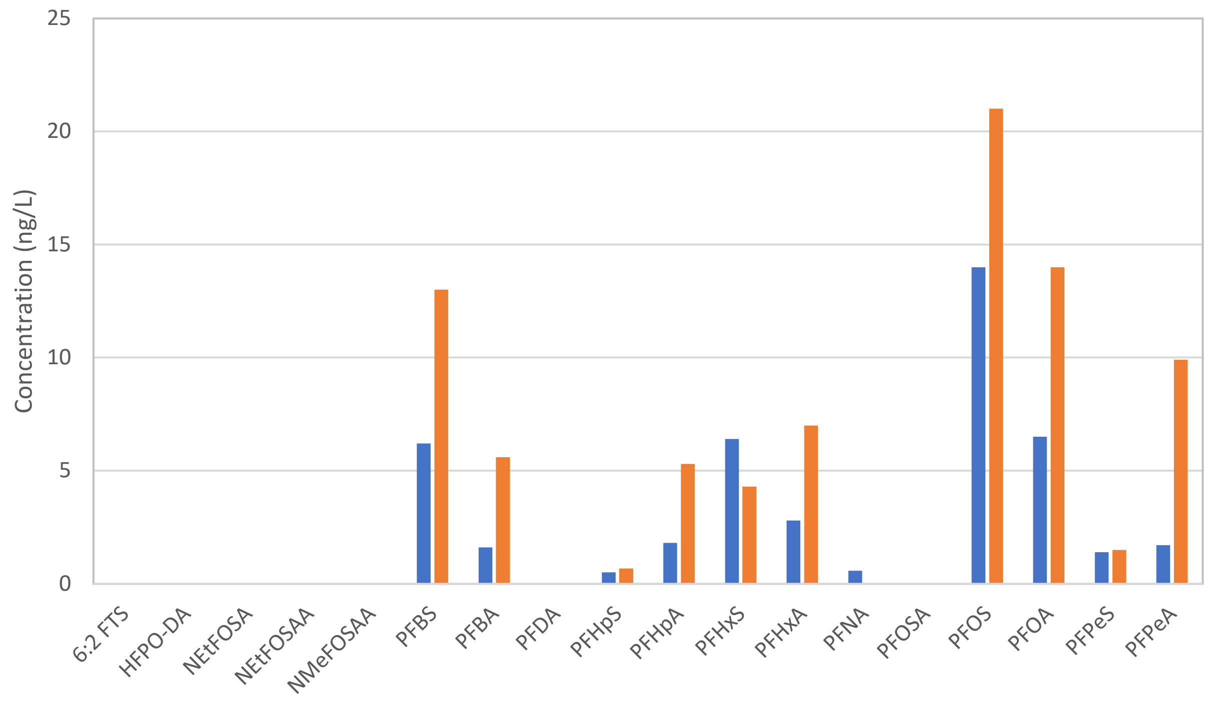
MODERATE EVIDENCE

DSCA PFAS Pilot Study
Site DC340005
Site Category: Moderate evidence of PFAS impacts from dry-cleaning operations

Note that graphs include:
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).



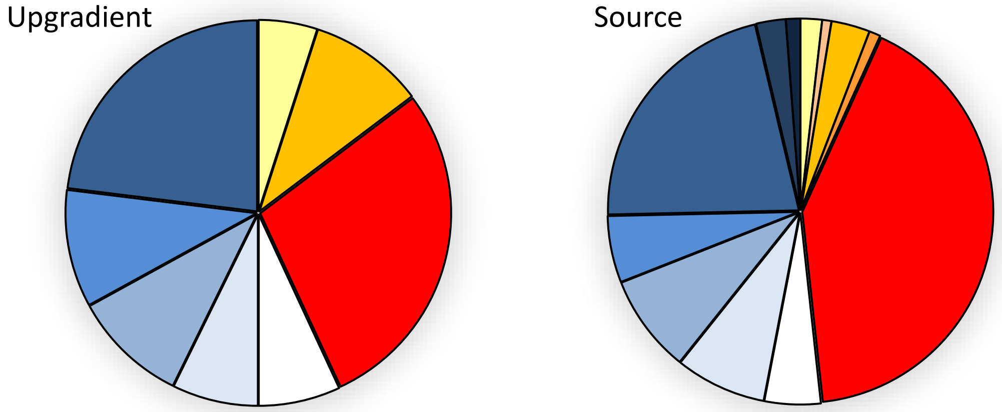




MODERATE EVIDENCE

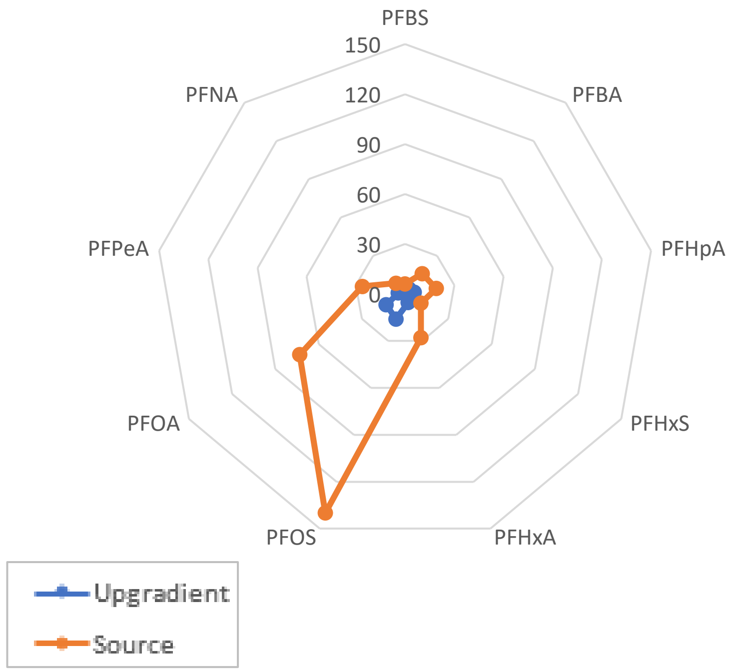
DSCA PFAS Pilot Study
Site DC410009
Site Category: Moderate evidence of PFAS impacts from dry-cleaning operations

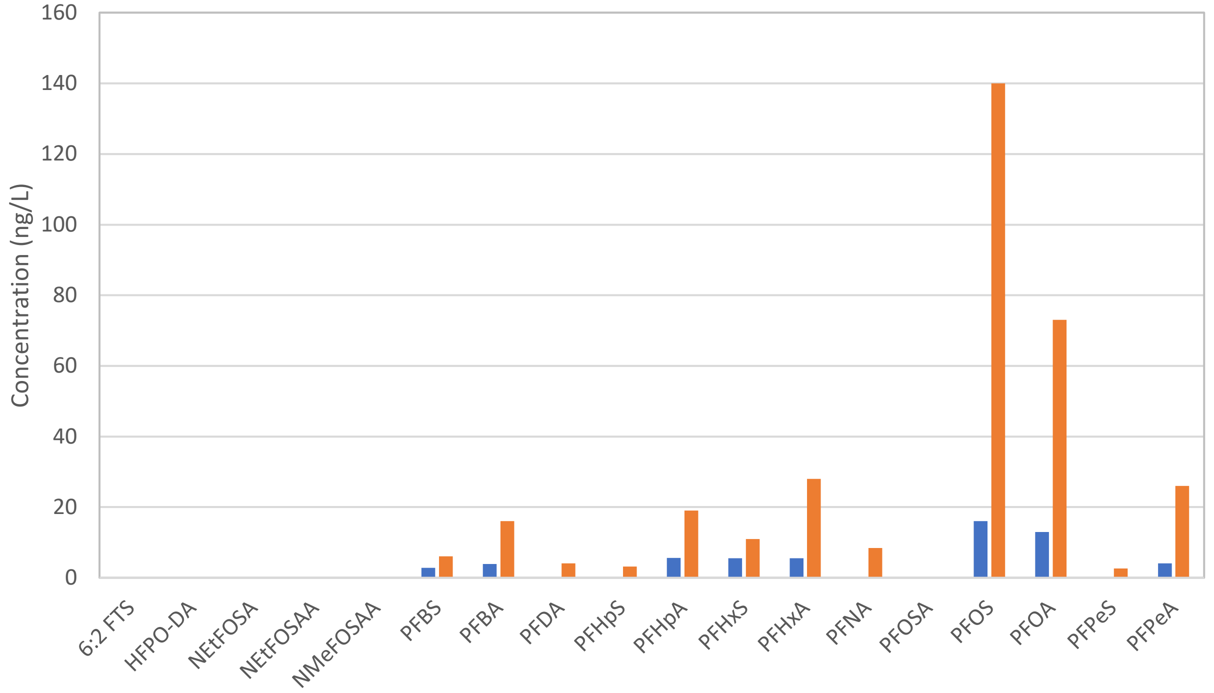
Note that graphs include:
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).



MW-2RS (SOURCE)	
PFOS	140 ng/L
PFOA	73 ng/L

MW-15S (UPGRADIENT)	
PFOS	16 ng/L
PFOA	13 ng/L

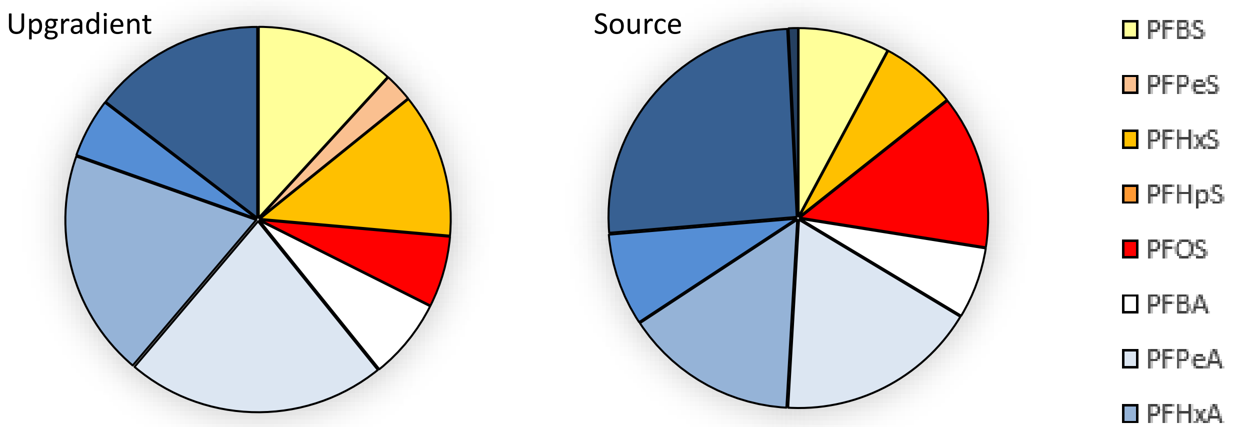


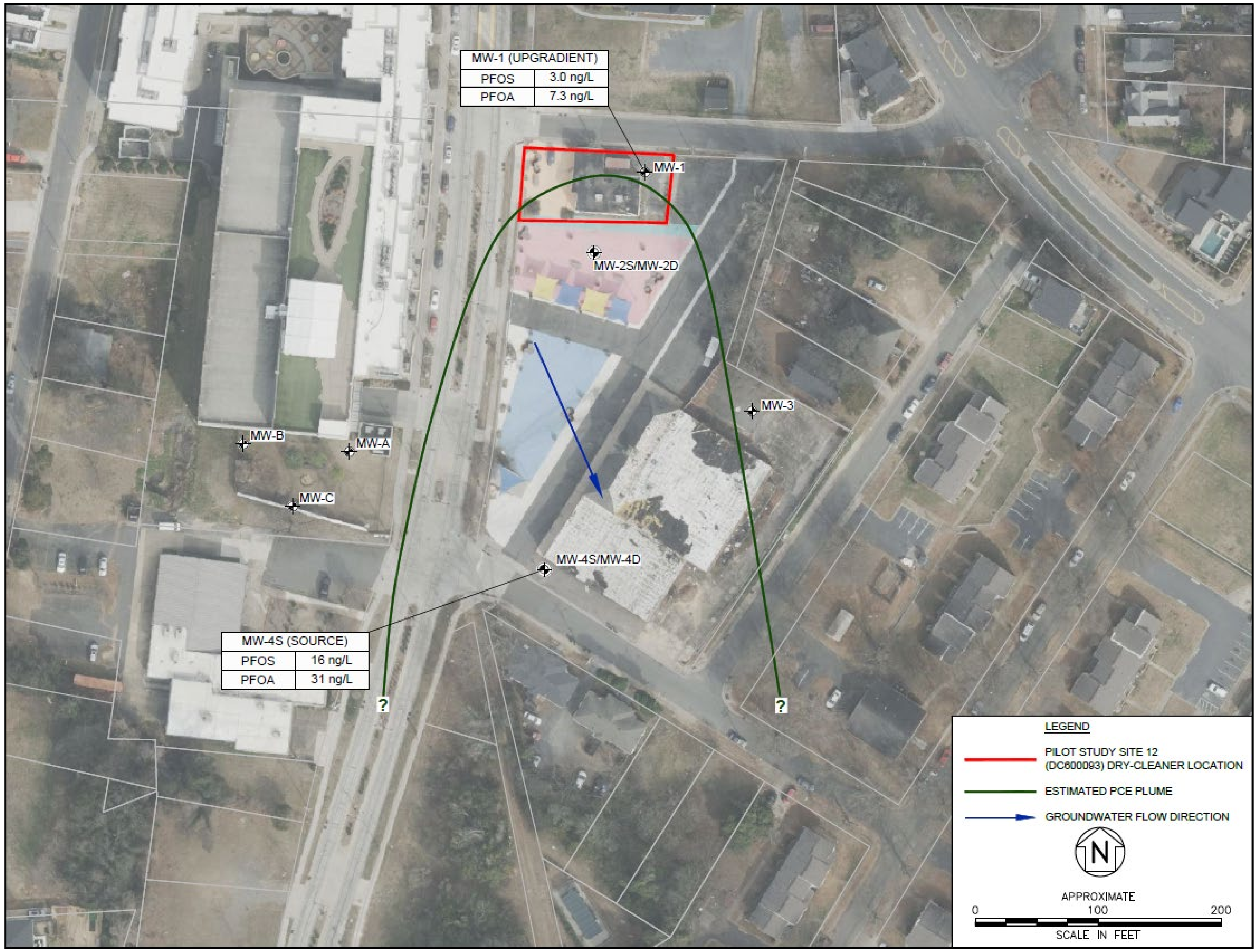


MODERATE EVIDENCE

DSCA PFAS Pilot Study
Site DC600093
Site Category: Moderate evidence of PFAS impacts from dry-cleaning operations

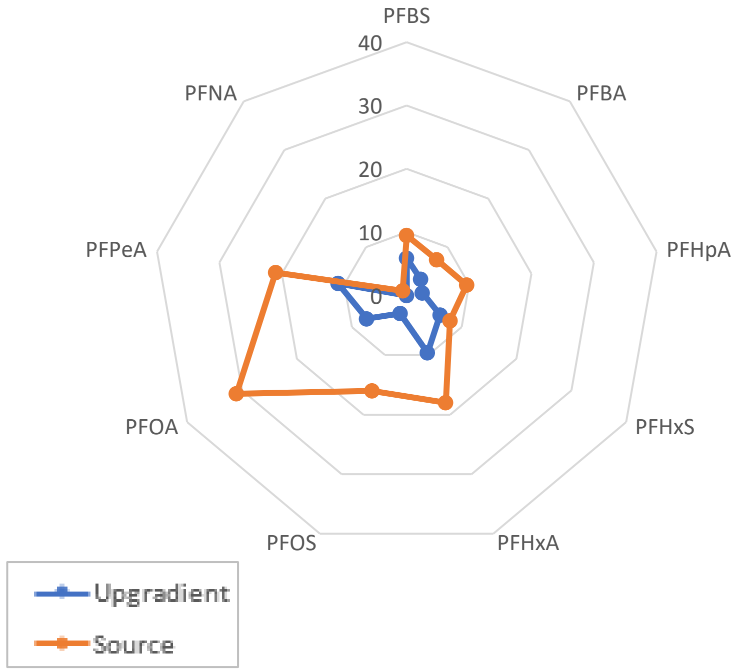
Note that graphs include:
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).

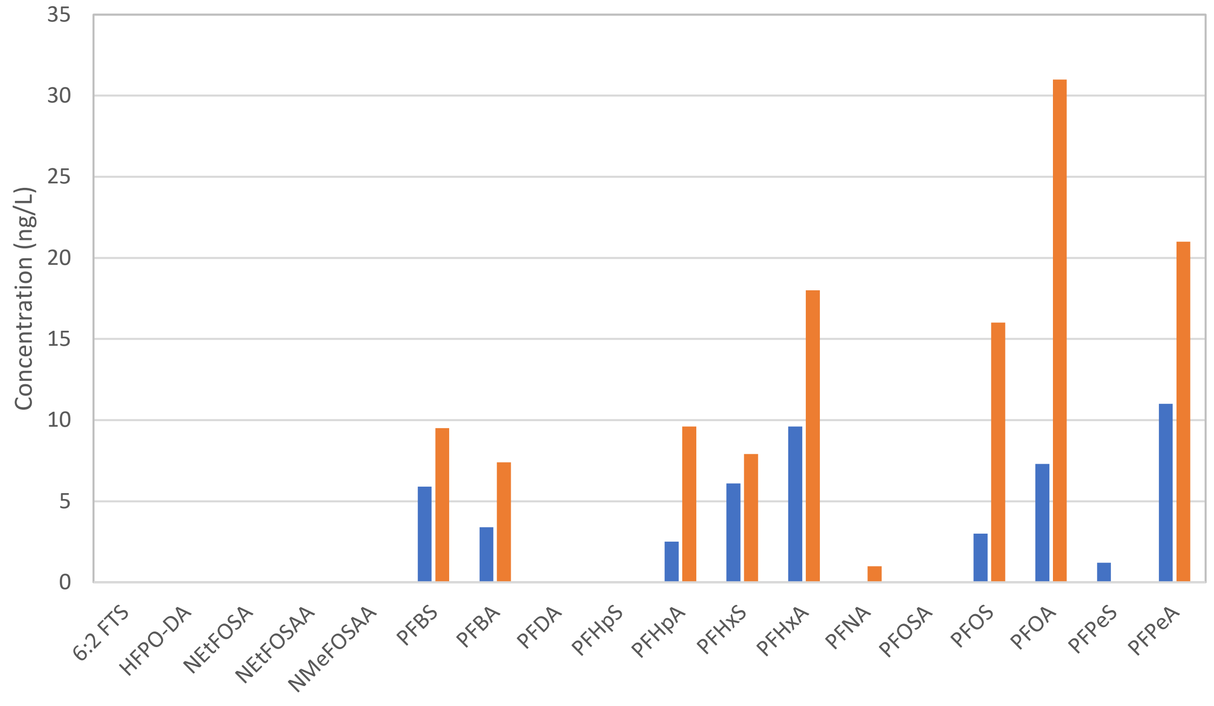




MW-1 (UPGRADIENT)	
PFOS	3.0 ng/L
PFOA	7.3 ng/L

MW-4S (SOURCE)	
PFOS	16 ng/L
PFOA	31 ng/L

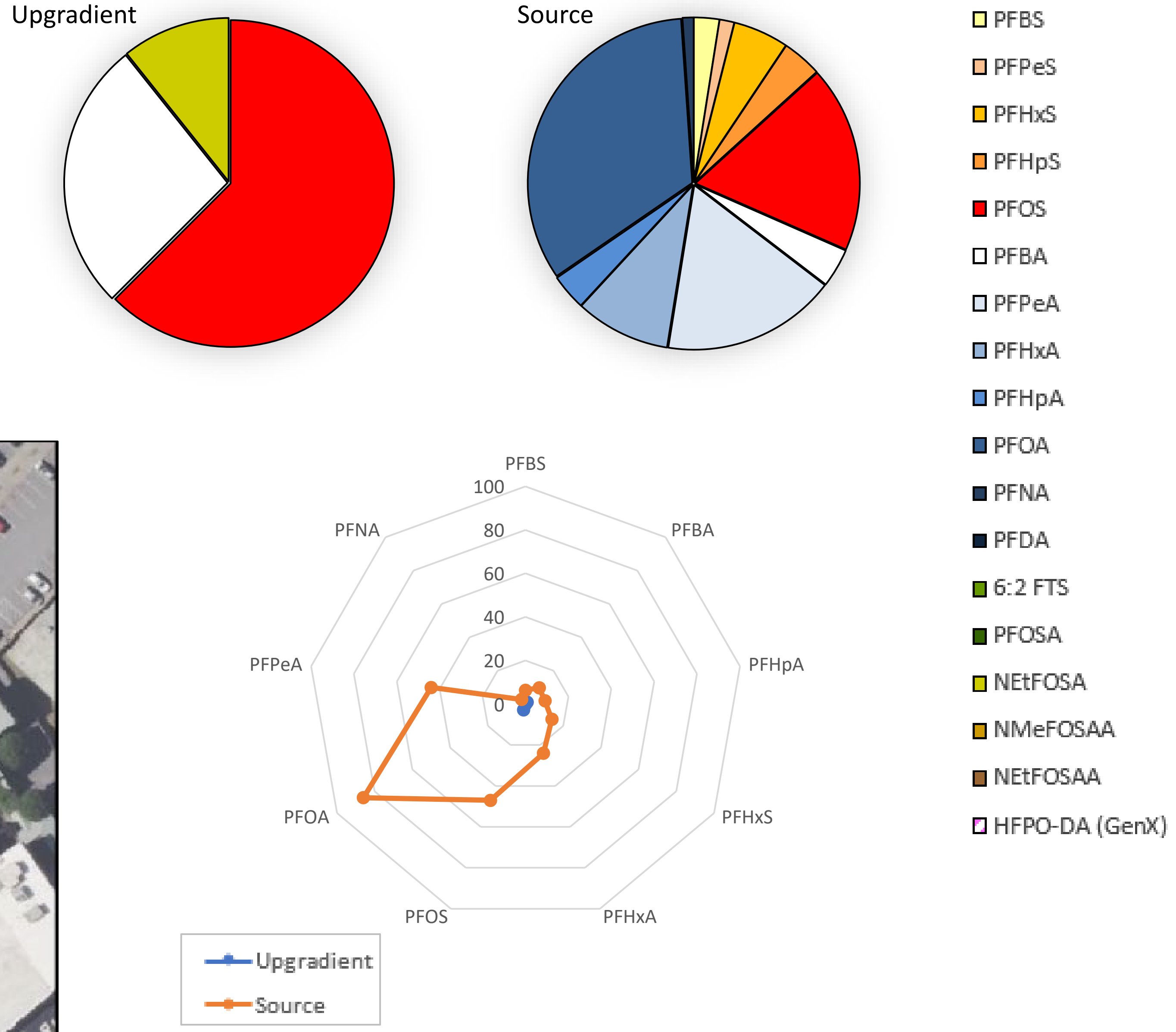


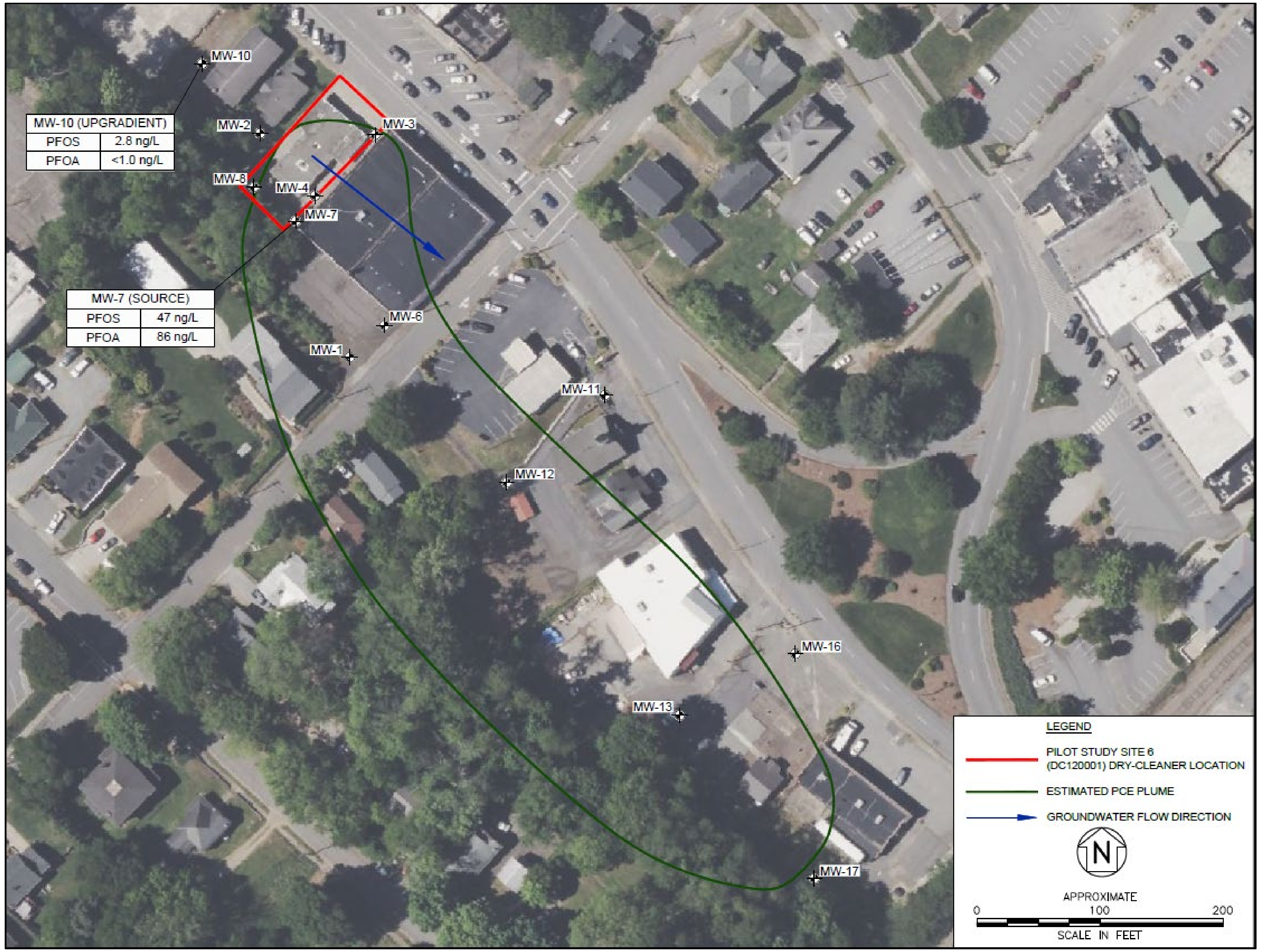


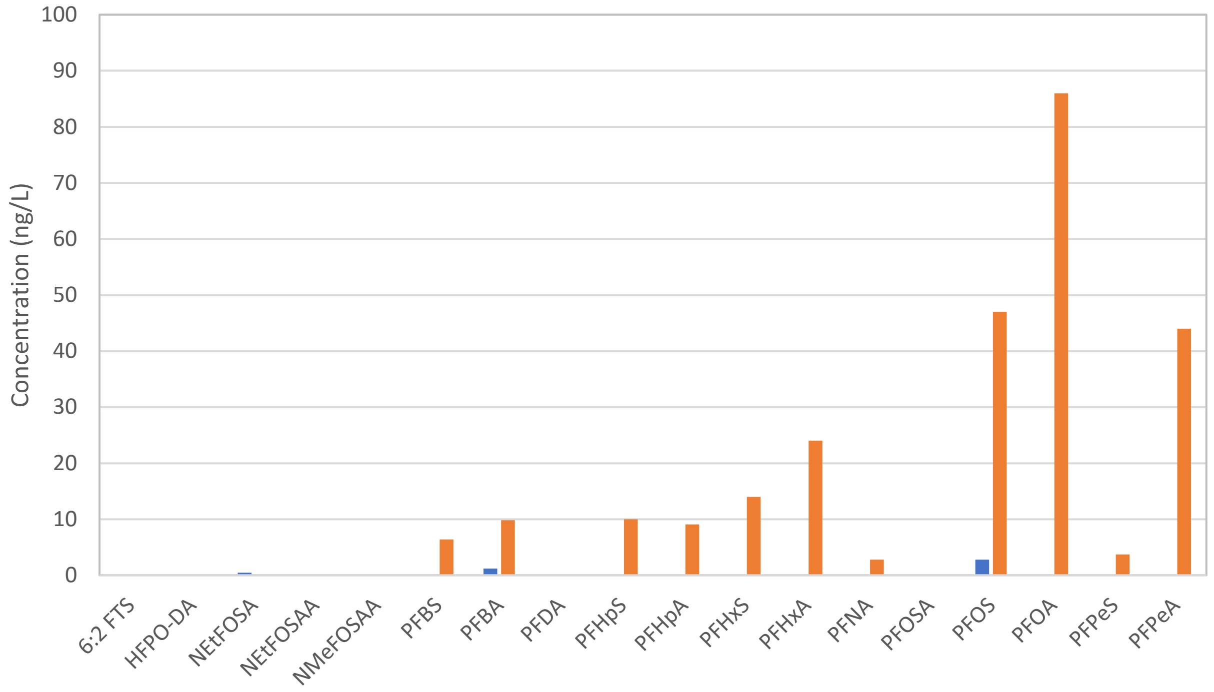
STRONG EVIDENCE

DSCA PFAS Pilot Study
Site DC120001
Site Category: Strong evidence of PFAS impacts from dry-cleaning operations

Note that graphs include:
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).



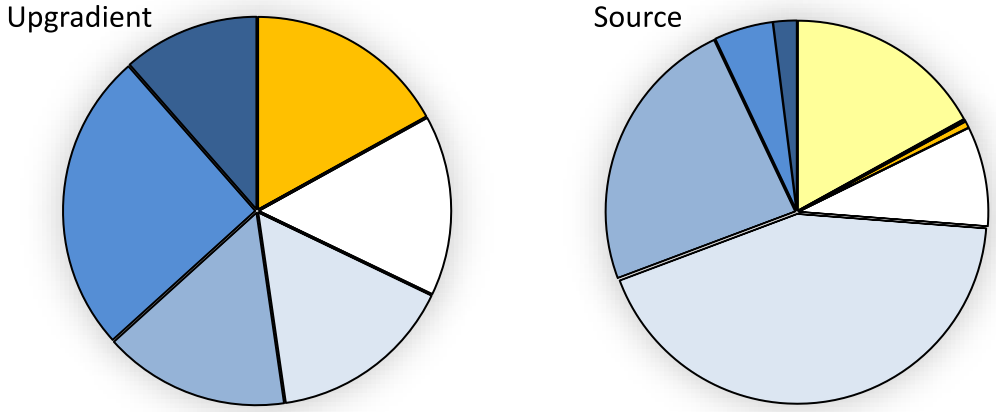


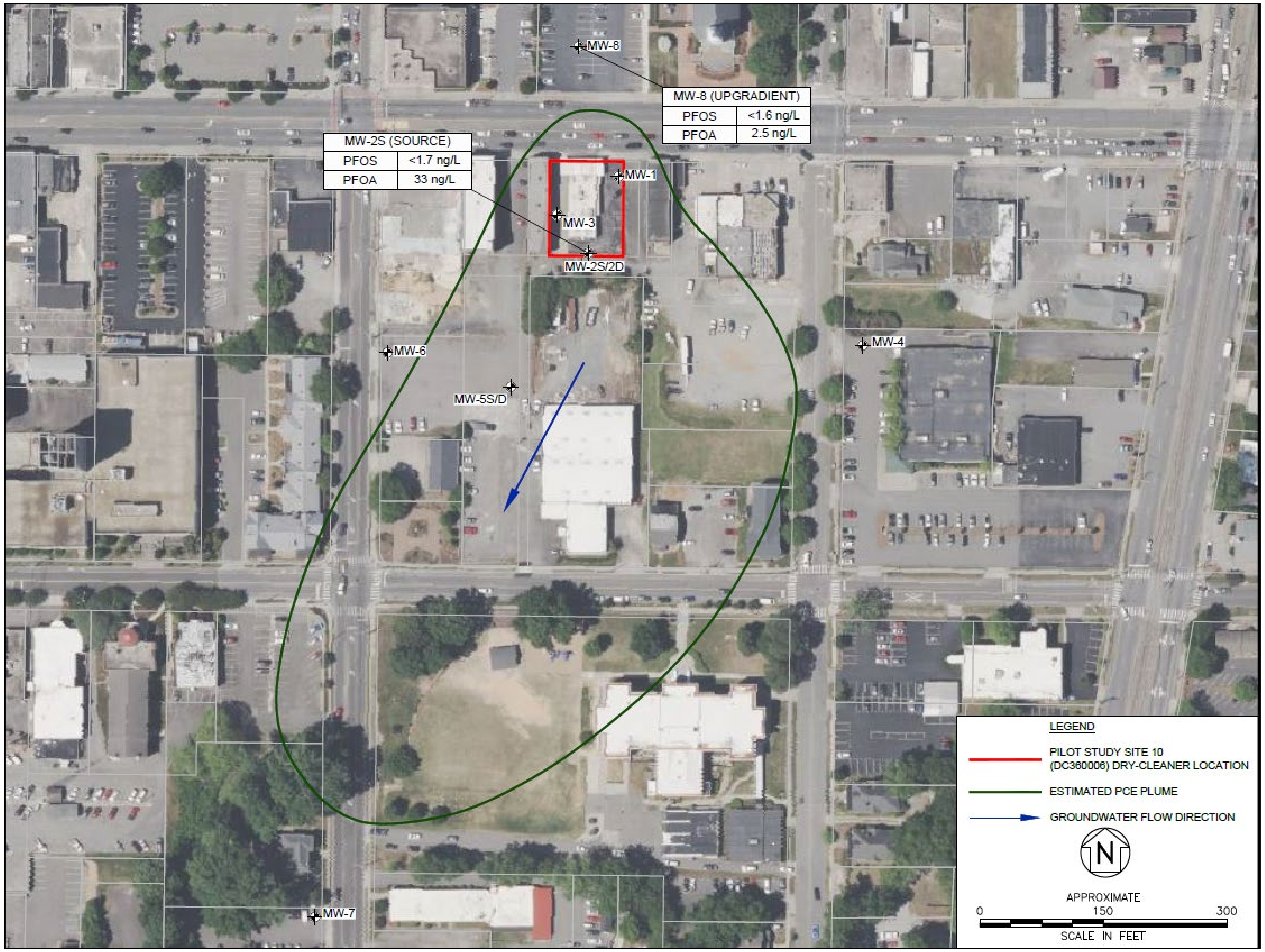


STRONG EVIDENCE

DSCA PFAS Pilot Study
Site DC360006
Site Category: Strong evidence of PFAS impacts from dry-cleaning operations

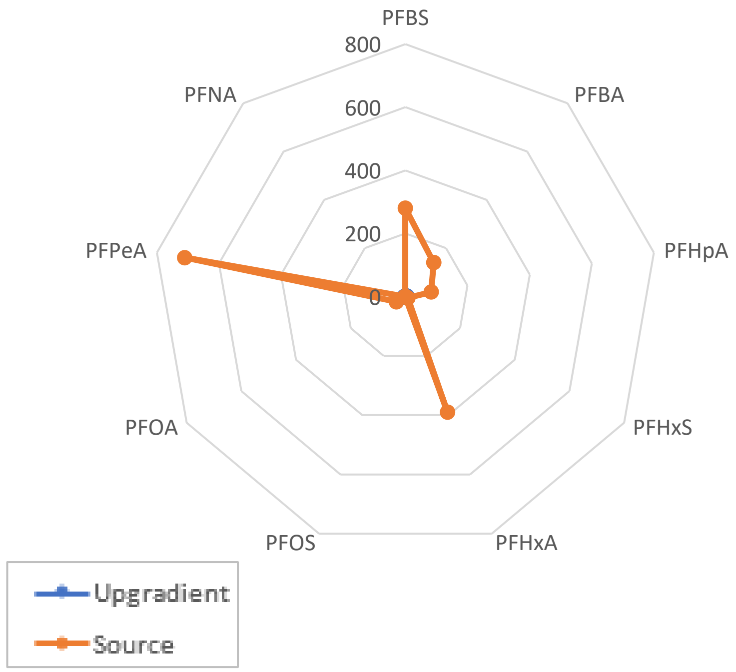
Note that graphs include:
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).

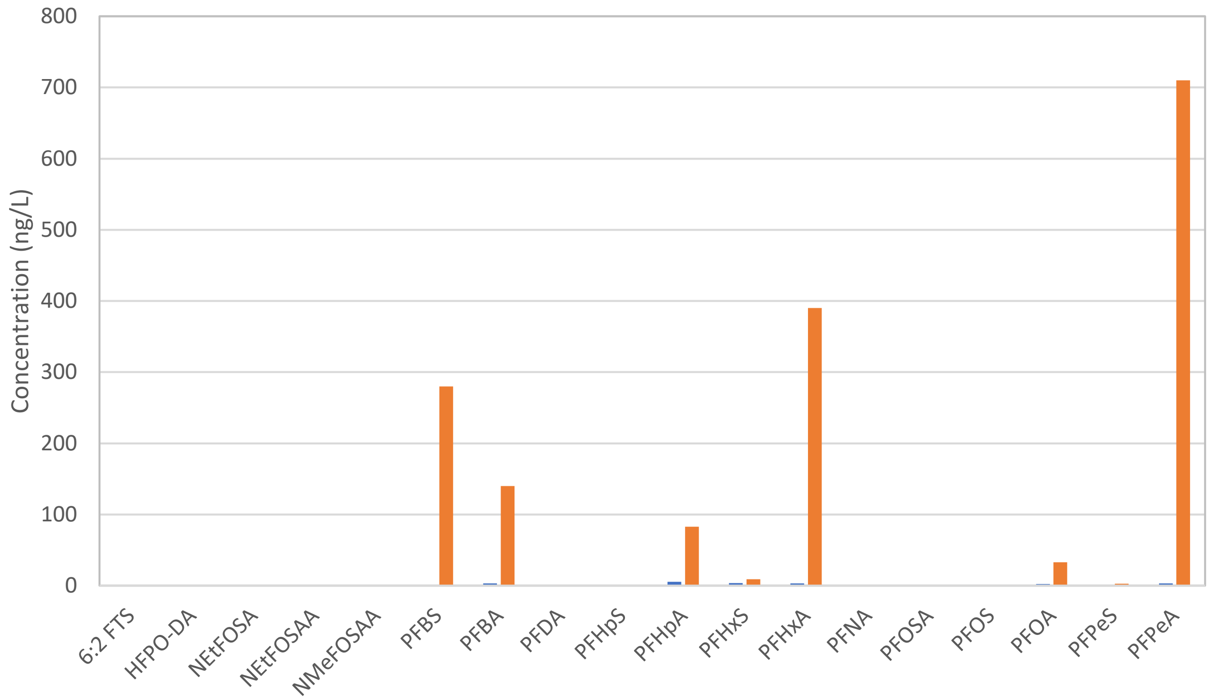




MW-8 (UPGRADIENT)	
PFOS	<1.6 ng/L
PFOA	2.5 ng/L

MW-2S (SOURCE)	
PFOS	<1.7 ng/L
PFOA	33 ng/L

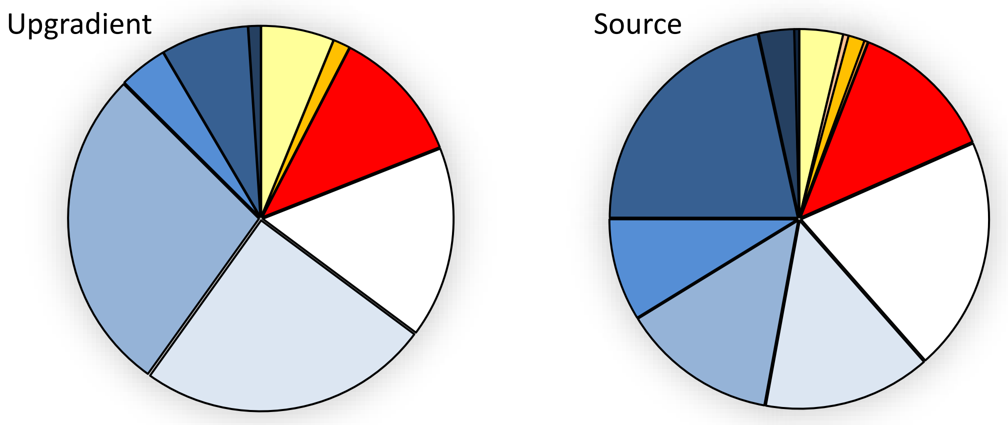




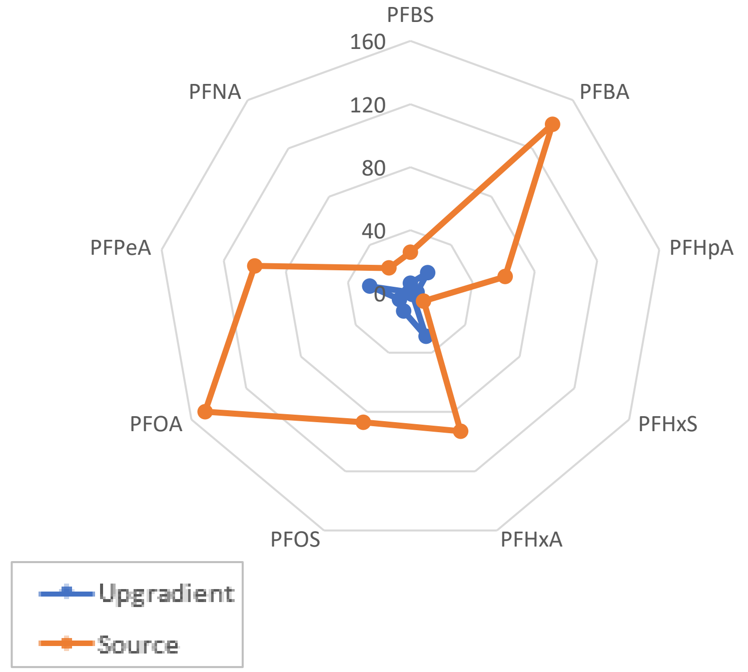
STRONG EVIDENCE

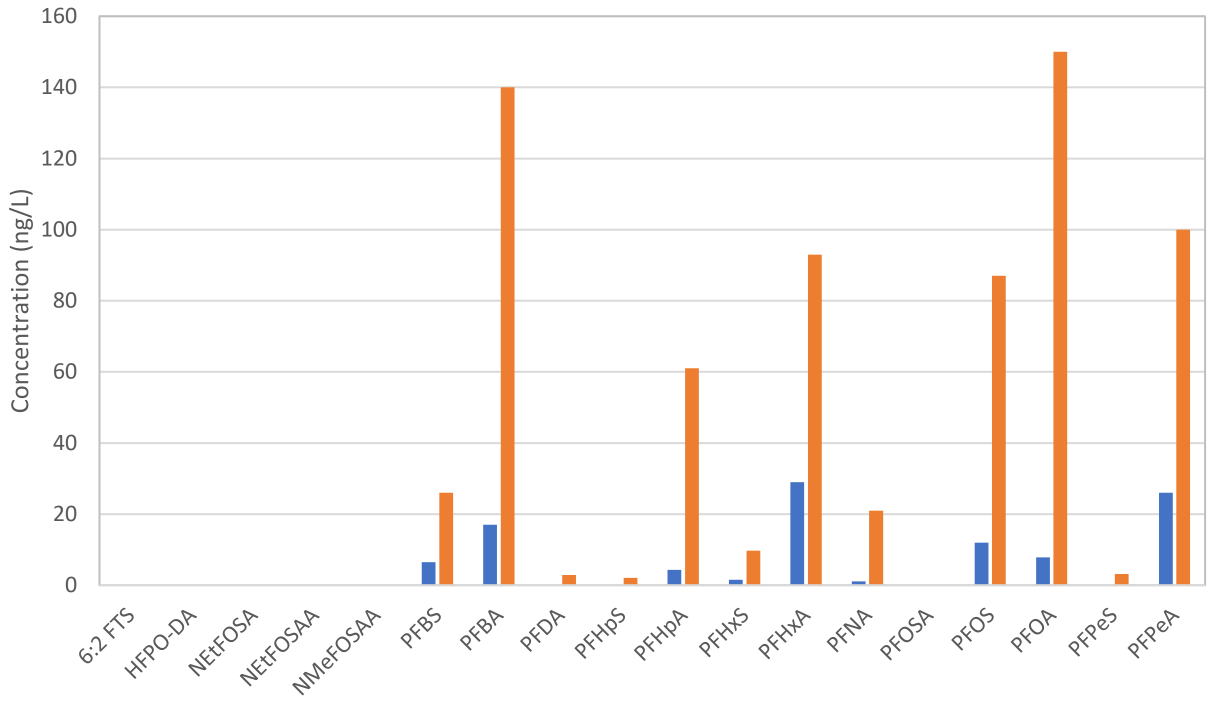
DSCA PFAS Pilot Study
Site DC320038
Site Category: Strong evidence of PFAS impacts from dry-cleaning operations

Note that graphs include:
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).



☐ PFBS
☐ PFPeS
☐ PFHxS
☐ PFHpS
☐ PFOS
☐ PFBA
☐ PFPeA
☐ PFHxA
☐ PFHpA
☐ PFOA
☐ PFNA
☐ PFDA
☐ 6:2 FTS
☐ PFOSA
☐ NEtFOSA
☐ NMeFOSAA
☐ NEtFOSAA
☐ HFPO-DA (GenX)

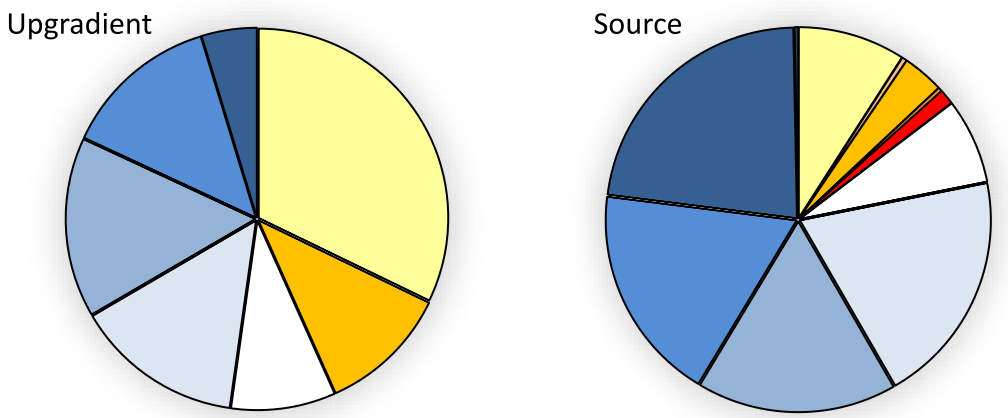




STRONG EVIDENCE

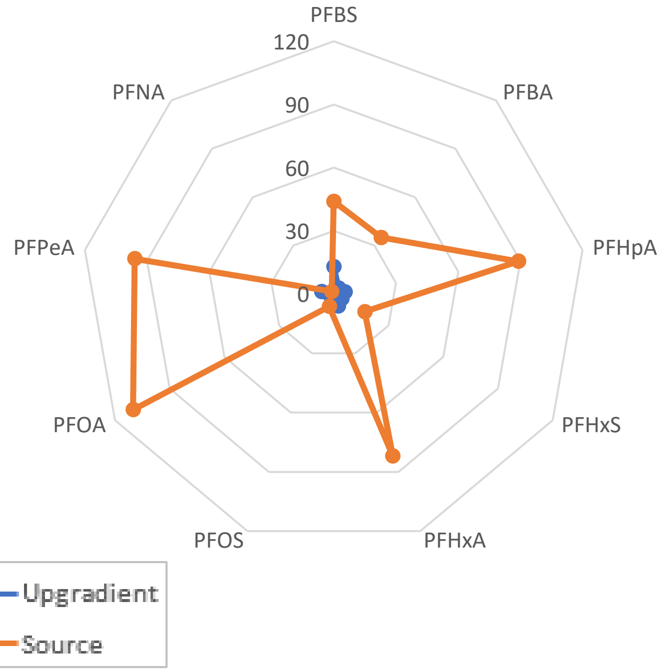
DSCA PFAS Pilot Study
Site DC920051
Site Category: Strong evidence of PFAS impacts from dry-cleaning operations

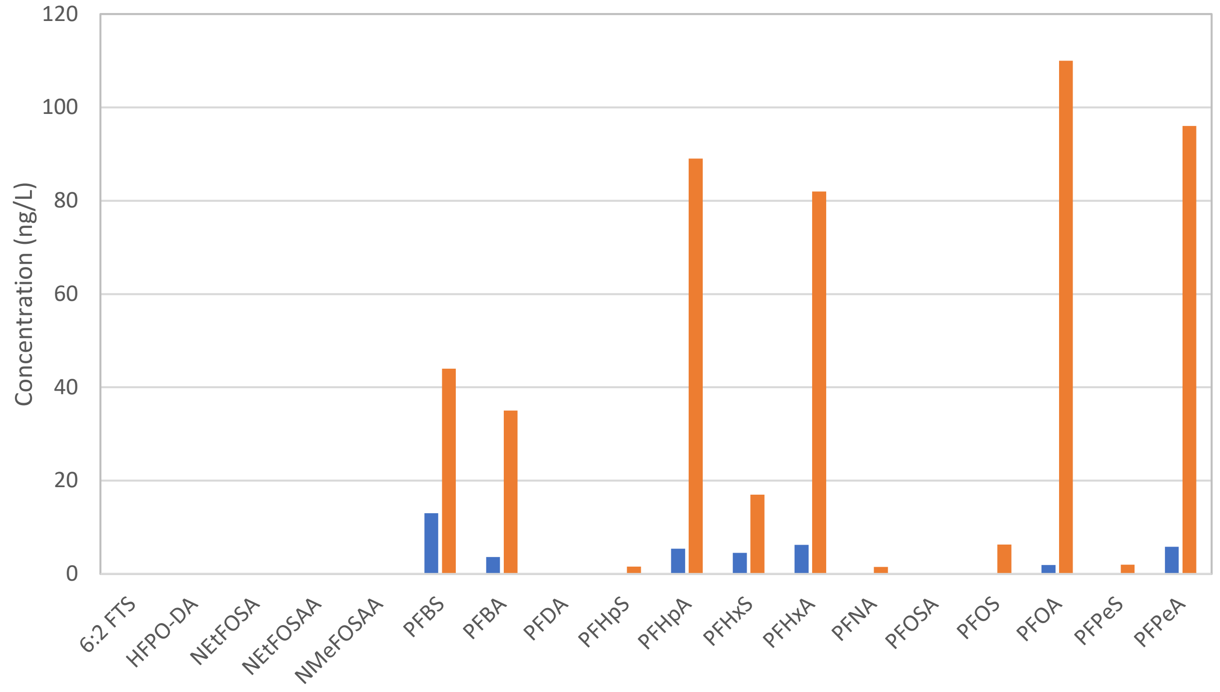
Note that graphs include:
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).



MW-1S (UPGRADIENT)	
PFOS	<1.7 ng/L
PFOA	1.9 ng/L

MW-6 (SOURCE)	
PFOS	6.3 ng/L
PFOA	110 ng/L

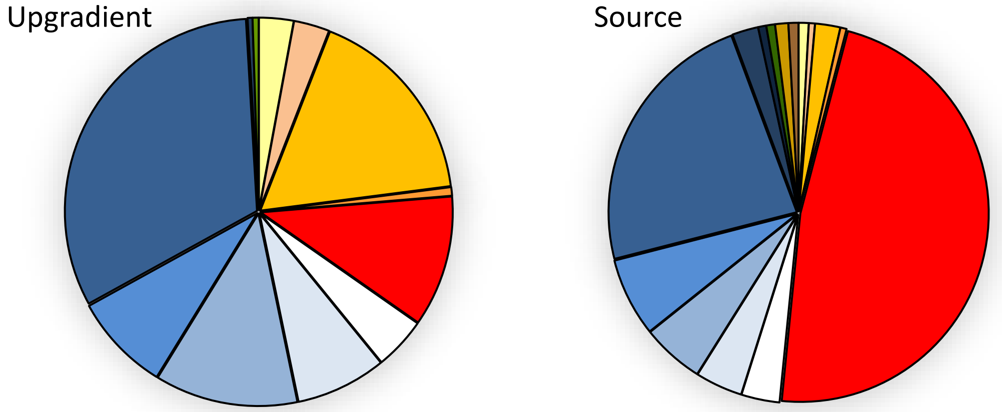


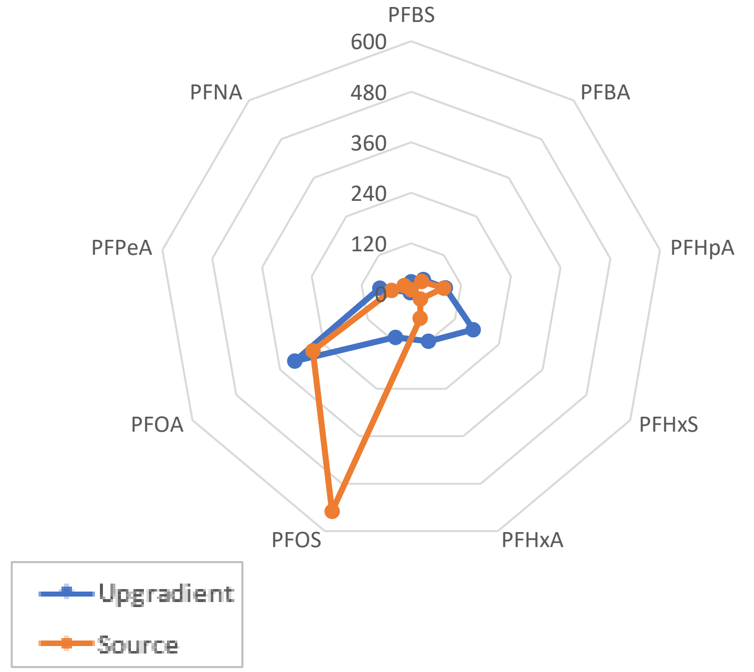


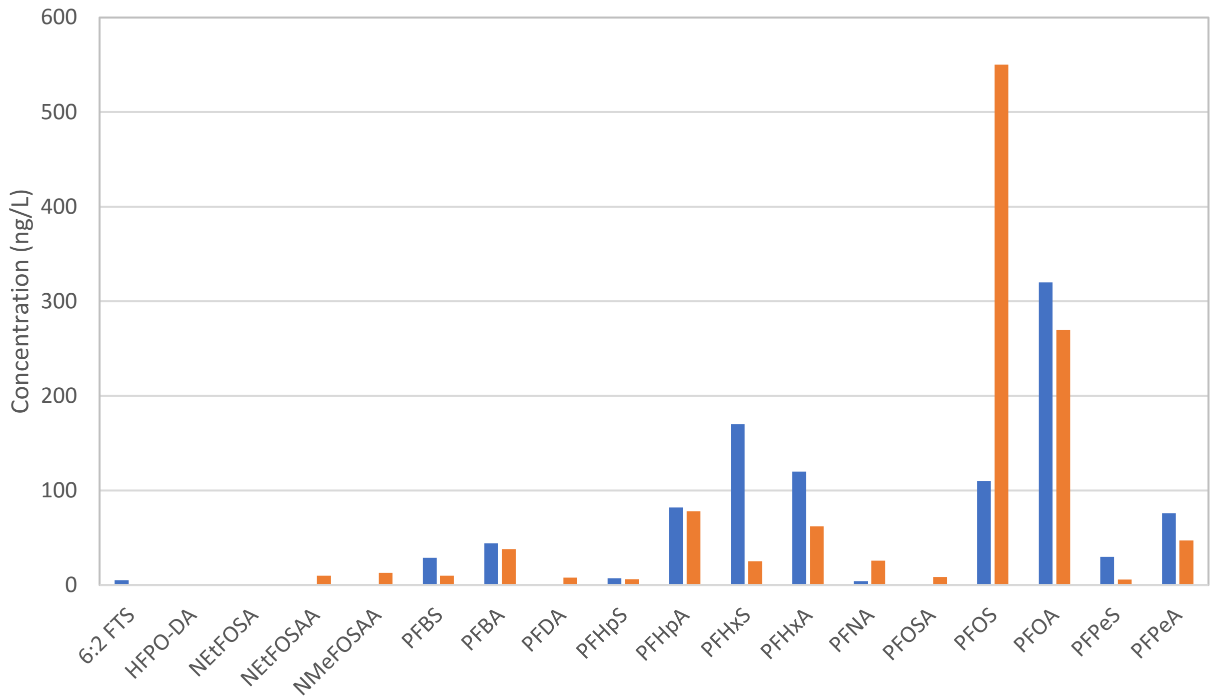
INCONCLUSIVE EVIDENCE

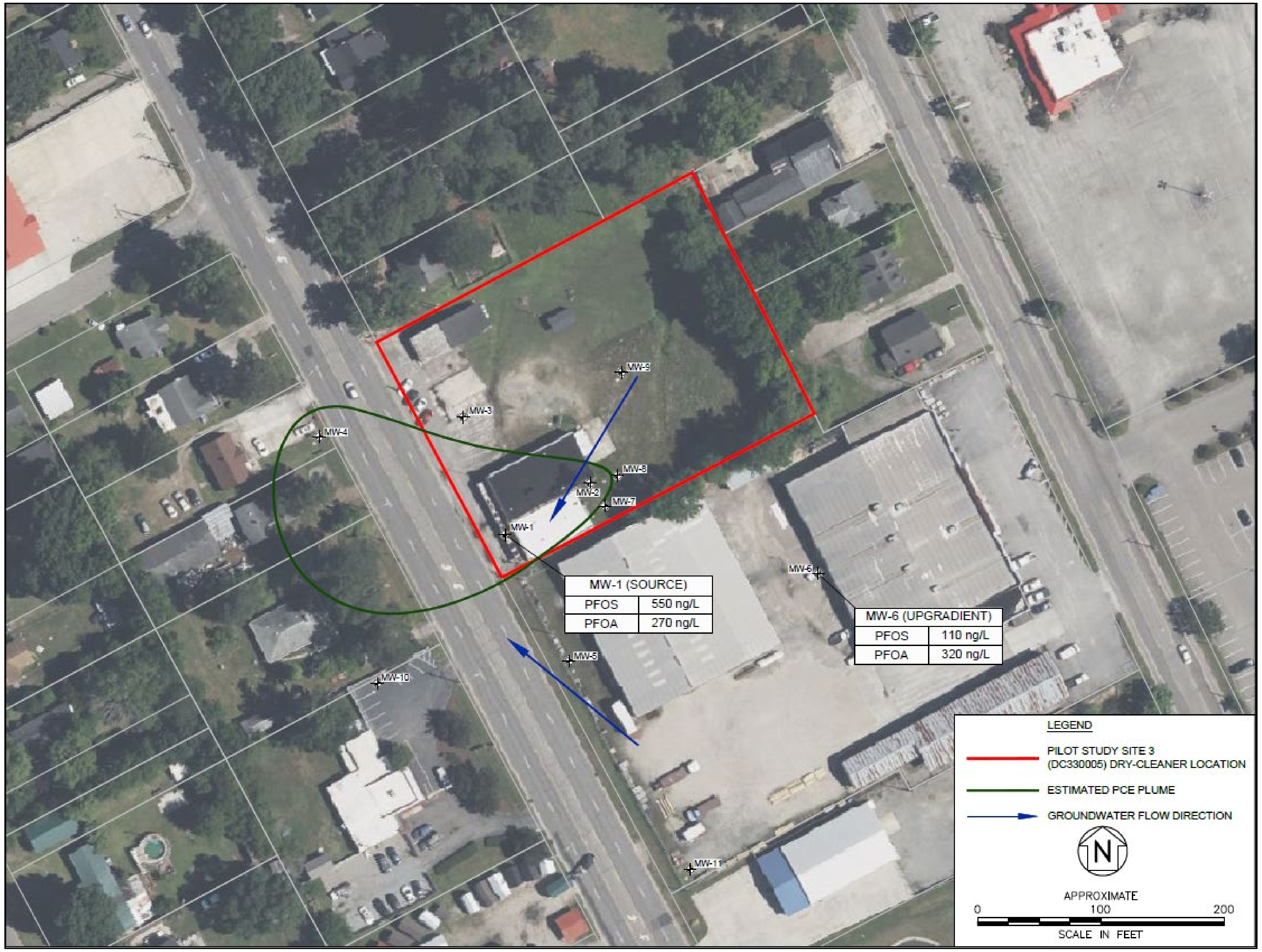
DSCA PFAS Pilot Study
Site DC330005
Site Category: Inconclusive evidence of PFAS impacts from dry-cleaning operations

Note that graphs include:
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).









MW-1 (SOURCE)	
PFOS	550 ng/L
PFOA	270 ng/L

MW-6 (UPGRADIENT)	
PFOS	110 ng/L
PFOA	320 ng/L

LEGEND

🟥 PILOT STUDY SITE 3 (DC330005) DRY-CLEANER LOCATION

🟩 ESTIMATED PCE PLUME

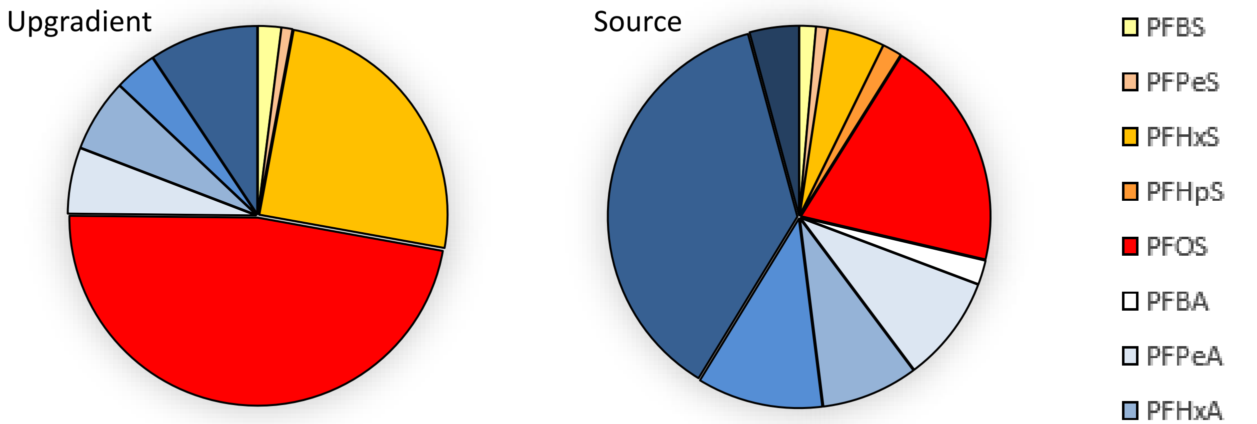
→ GROUNDWATER FLOW DIRECTION

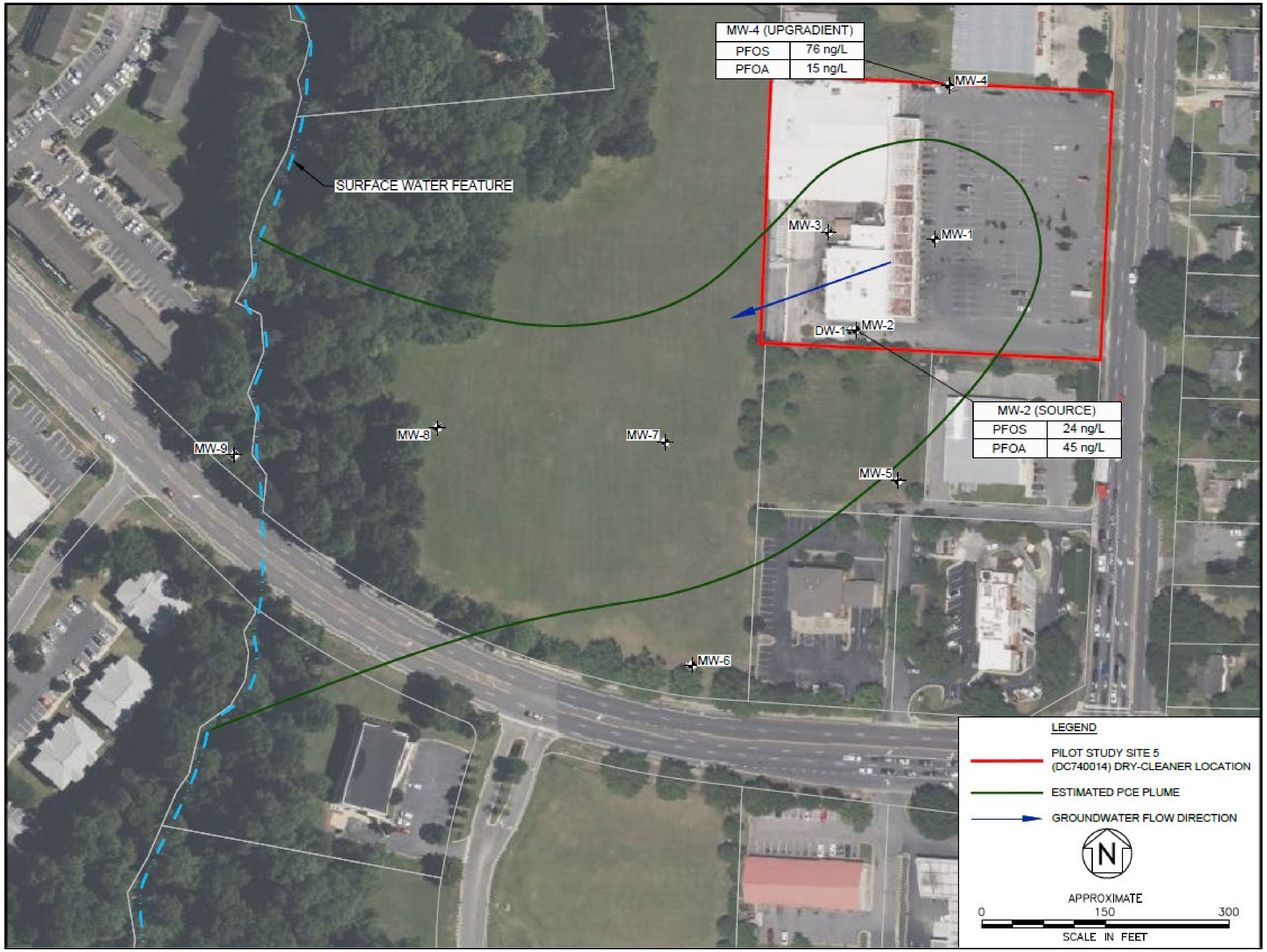
APPROXIMATE
0 100 200
SCALE IN FEET

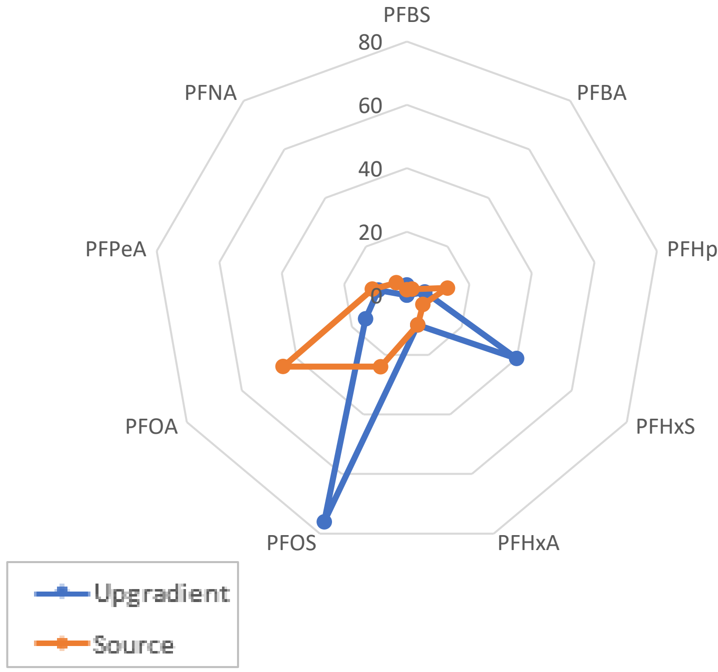
INCONCLUSIVE EVIDENCE

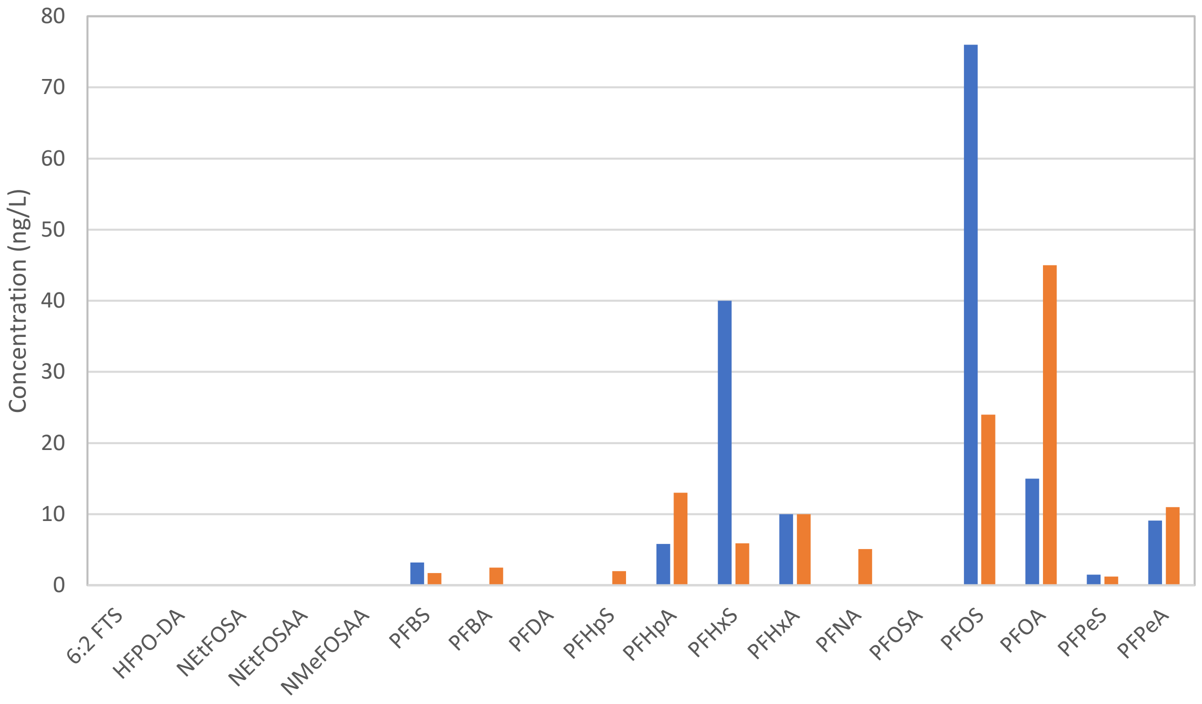
DSCA PFAS Pilot Study
Site DC740014
Site Category: Inconclusive evidence of PFAS impacts from dry-cleaning operations

Note that graphs include:
1. NCDEQ Signature Tool graphs showing detected constituent percentages in each sample.
2. Radar graph showing concentrations for key constituents in ng/L (or ppt).
3. Bar graph showing concentrations for key constituents in ng/L (or ppt).









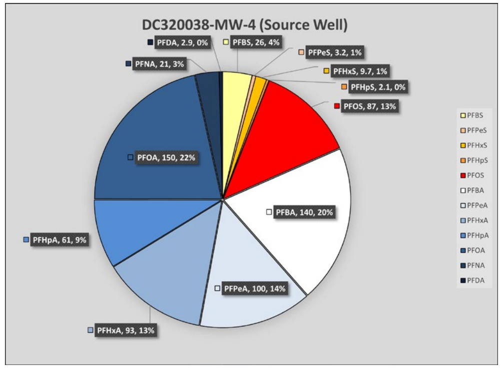
DRAFT

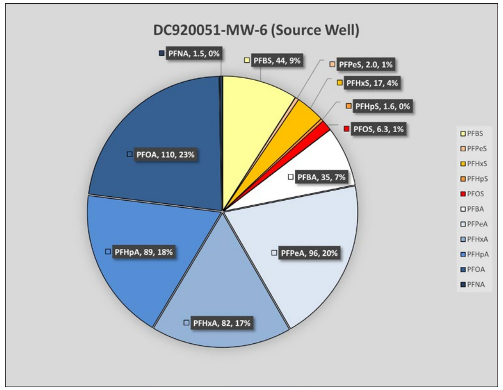
Attachment 2

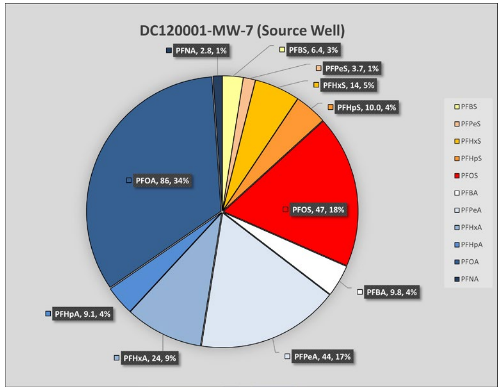
Additional PFAS Signature Tool Graphs

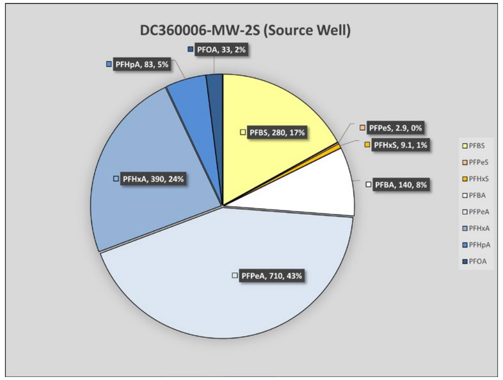
DSCA PFAS Pilot Study
Signature Tool Graphs
Source wells at sites with moderate or strong evidence of PFAS impacts from dry-cleaning operations

MODERATE EVIDENCE

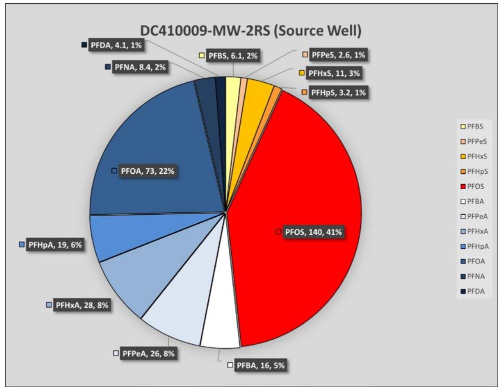


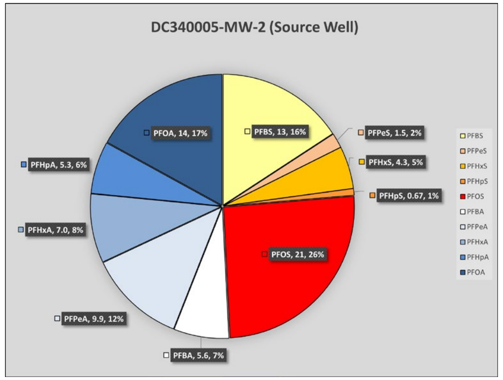


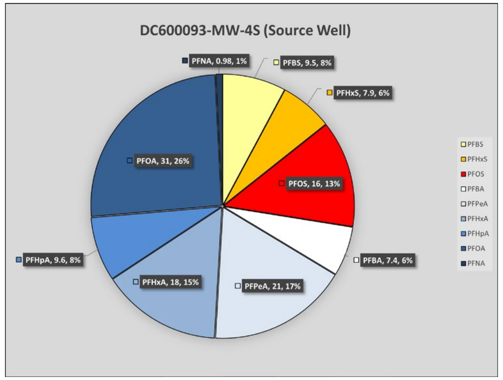




STRONG EVIDENCE







DSCA PFAS Pilot Study
Signature Tool Graphs
Used Solvent Samples